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HYDRAULIC MODEL STUDIES OF BOULDER CREEK SUPPLY CANAL DRAINAGE INLETS AND OVERFLOW WEIR SECTIONS

Hydraulic Laboratory Report No. Hyd-407

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

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CONTENTS

CONTENTS--Continued

FOREWORD

Hydraulic model studies of the Boulder Creek Supply Canal, a part of the Colorado-Big Thompson Project, were conducted in the Hydraulic Laboratory of the Bureau of Reclamation at Denver, Colorado, during the period May 1953 to October 1953.

The final plans evolved from this study were developed through the cooperation of the Canals Branch and the Hydraulic Laboratory.

During the course of the model studies, Messrs. H. K. Brickey, G. W. Birch, and B. A. Prichard of the Canals Branch frequently visited the laboratory to observe the model tests and discuss the results.

These studies were conducted by G. L. Beichley under the supervision of A. J. Peterka and J. N. Bradley under the Hydraulic Laboratory direction of H. M. Martin.

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Subject: Hydraulic model studies of Boulder Creek Supply Canal drainage inlets and overflow weir sections

SUMMARY

Hydraulic model studies of the Boulder Creek Supply Canal, Figures 1 through 4, were made on a 1:12 scale model, Figures 5, 6, and 7, of the portion of canal between Stations 454+18 and 462+34, Figure 8. This portion of the canal included two drainage inlets and two overflow sections. The drainage inlets are used to introduce drainage water from the adjacent watersheds into the canal. The overflow weirs are used to discharge the drainage flow into natural ravines on the opposite side of the canal from which the flow entered. In no case is the weir directly opposite the inlet. The purpose of the model study was to investigate the hydraulic performance of this system and to apply the results to the entire Boulder Creek Supply Canal system to predict its performance and adequacy.

The horizontal bends of the prototype canal were not reproduced. Instead, the model canal was constructed in a straight line to simplify the model construction and to supply general data that would be applicable to other reaches of canal containing similar structures.

The performance of the inlets was investigated and found to be acceptable as originally designed, Figures 10, 11, and 12; however, stilling action was improved in the model by shortening the basins and using baffle piers in place of chute blocks, Figures 3, 11, and 12.

The overflow weir sections, Figures 4 and 5, performed, in general, as expected but the tests showed that their capacity and location were not entirely satisfactory. Several factors were found to influence the quantity of flow discharged by each weir.

The efficiency of a single weir was determined by computing the coefficient of discharge, Figures 16 and 17, based on water surface elevations measured in the canal upstream and downstream of the weir. The coefficient varied considerably depending on the relative locations

of the weir and inlet, the length of weir, and the quantity of flow in the canal. In general, a weir was more efficient, i.e., had a larger discharge coefficient, for larger discharges, Figure 16. A short weir was more efficient than a long one, Figure 16, and a single weir was more efficient when located upstream rather than downstream from an inlet, Figures 16, 17, 18, and 19. Also, the depth of flow in the canal upstream from an inlet was reduced by locating the weir upstream from the inlet, Figure 19. In either location, however, the canal flow depth immediately upstream of the weir was always less than immediately downstream.

The efficiency of two weirs discharging was determined by measuring the percent of total drainage inflow in excess of 20 second-feet being discharged by the two model weirs when the canal was carrying its normal capacity of 200 second-feet in addition to the drainage inflow. The first 20 second-feet of drainage inflow was not considered in figuring the percent of drainage inflow discharged by the weirs because it is needed to increase the depth of flow in the canal to the crest of the overflow weirs. The two model overflow weirs together were found to be capable of discharging at least 88 percent of the total drainage inflow in excess of 20 second-feet, depending on the total quantity of drainage flow into the canal, Figure 21. The percentage is higher with less drainage inflow.

It was found that shortening or eliminating a weir will increase considerably the discharge of the other weirs either upstream or down, but the total discharge is reduced. It was also found that two weirs spaced some distance apart with an inlet between is better than one weir equal to the total length of the two.

Using the data from the modeled portion of the canal, the efficiency of the entire system of prototype weirs in discharging the drainage inflow was analyzed and checked to a reasonable degree using two different methods. The capacity of the four preliminary weirs, as determined by these analyses, did not appear to be sufficient to prevent the flow in the canal from overtopping the canal banks. However, the quantity of drainage flow remaining in the canal downstream from the last weir was acceptable because it was less than the capacity of the siphon provided downstream at Station 585+00 for discharging excess drainage flow from the canal.

To prevent overtopping of the canal banks, two weirs were added to the preliminary design making a total of six overflow weirs. In addition, the weir at Station 360+00 was relocated from downstream of the inlet to upstream of the inlet at Station 356+92 to reduce the flow depth upstream of the inlet at Station 358+95 and to increase its capacity. The arrangement of weirs and inlets recommended for prototype construction is shown in Figure 1, and the estimated performance of the recommended system is shown in Figure 26.

INTRODUCTION

Boulder Creek Supply Canal is a part of the Colorado-Big Thompson Project. It is situated south of Lyons, Colorado, in Boulder County as shown on the location map, Figure 1. The canal is approximately 15.5 miles long. It is partially earth lined and partially unlined in earth. The canal bottom is 12 feet wide and slopes downstream at the rate of 0.0003 foot per foot, as shown in Figure 2. The canal section is 6.8 feet deep with the embankment being compacted to a height of 5.5 feet above the canal bottom. The canal is designed to discharge a normal flow of 200 second-feet at a velocity of 2.37 feet per second and a depth of 4.59 feet.

Initially, the canal was to contain 7 concrete drainage inlet structures and 4 concrete overflow weir sections, Figure 8, but was revised as a result of this investigation to contain 6 overflow weir sections situated as shown in Figure 1. The inlets and overflow weirs recommended for prototype construction are shown in Figures 3 and 4.

The largest inlet was designed for 273 second-feet; the smallest for 52 second-feet. Crest lengths for the overflow sections varied from 102 to 163 feet. The weir crest height above the canal bottom in all cases was 4 feet 9-5/8 inches, which allows a discharge of approximately 220 second-feet to occur in the canal before flow is discharged through the overflow weir sections.

About 2-1/2 miles downstream from the last overflow section a siphon wasteway is provided in the canal, as shown in Figure 1, at Station 585+00. Excess drainage flow that is not discharged by the overflow sections can be discharged here. Since the siphon is designed to discharge not more than 100 second-feet, the overflow weirs must discharge most of the drainage water that enters the canal.

THE MODEL

The model, Figures 5, 6, and 7, was constructed and tested in the Bureau of Reclamation's Hydraulic Laboratory at the Denver Federal Center. It was a 1:12 scale model of the canal, including drainage inlets and overflow weirs between Stations 454+18 and 462+34, Figure 7.

The prototype canal, Figure 8, contained numerous curves but the model was constructed in a straight line as shown in Figures 5 and 7. Curves were eliminated to simplify model construction and to supply more general answers concerning the efficiency of the inlet and overflow system in other reaches of the canal containing similar inlets and overflow weirs. Data of a general nature might also be useful in the design of future canal structures of this type.

This particular portion of the canal was chosen for the study because it included more inlets and overflow sections than any other reach of canal of the same length. Too, it was felt that the model should include the inlet and overflow weir farthest downstream to determine more accurately how much flow might be expected to remain in the canal downstream from the last overflow weir.

The model canal including inlets and overflow weirs was constructed entirely of plywood with cemented joints to provide watertightness. Wire hardware cloth was tacked to the canal side slopes and bottom, at locations determined by trial, to produce uniform depths of flow from one end of the canal to the other when the inlets and overflow weirs were not operating.

Water for the normal flow in the canal was supplied by an 8-inch vertical pump through an 8-inch supply line at the upstream end of the model. This flow entered the canal from a 3-foot-square head box containing a 3-inch-thick rock type baffle. Water for the two drainage inlets was supplied by separate vertical pumps through 8-inch supply lines to head boxes at the entrance to each inlet.

Eight-inch orifice venturi meters were used in each of the three supply lines to measure the discharges. V-notch weir boxes were used to measure the discharge from each overflow weir, as shown in Figure 5. Point gages were used to measure the depth of flow at five locations, Figure 7, along the canal.

An automatic tail water control gate was developed for the model, Figure 6, in order to assimilate anticipated prototype flow conditions. The control gate was shaped by trial and error to automatically produce the calculated depth of flow, Figure 9, for discharges between 200 and 285 second-feet; 200 being the normal canal flow while 285, at the time of the test, was the anticipated maximum flow remaining in the canal downstream from the last overflow weir.

THE INVESTIGATION

The investigation was concerned primarily with the efficiency of the overflow weirs in removing a sufficient quantity of the drainage water from the canal. However, the investigation was also concerned with the performance of the inlet structures in admitting drainage water into the canal.

The Inlet Structures

Preliminary inlet. The preliminary inlet structures, Figure 10, performed acceptably in discharging the drainage flow into the canal, as shown in Figures 11 and 12. However, it was believed that the performance could be improved. The performance of two of the inlets is shown in Figures 11 and 12. A boil occurred almost directly above the vertical end sill of the inlet basin near the left bank of the canal. Waves and currents, therefore, along the left bank were greater than along the right. The chute blocks were so deeply submerged that they had no effect on the incoming flow.

Second inlet design. To reduce the turbulence near the left bank, the basin was shortened so that the end of the basin coincided with the canal center line. The chute blocks were also removed from the basin. The performance of this design is shown in Figures 11 and 12 and was better than the preliminary design. The boil occurred in the center of the canal and turbulence near and along the left bank was reduced.

Recommended inlet design. To minimize the boil which occurred near the canal center line with the second inlet design, 1-foot cubical baffle blocks were added to the inlet basin. The baffles were placed as shown in the recommended design in Figure 3. The performance of this basin is shown to be very good in Figures 11 and 12. The boil that previously occurred was reduced considerably, practically eliminating the turbulence and high velocities along the canal banks. The recommended inlets were used throughout the tests on the overflow weirs.

The Overflow Weirs

Efficiency of a single weir. The efficiency of a single weir was determined by calibrating each model weir separately and comparing the coefficients of discharge. Each weir in the model, Figure 7, was calibrated for full length and half length with the other weir closed. However, it was found impossible to obtain exactly similar coefficients for the two weirs because of the different locations of the weirs with respect to the other features of the model.

In calibrating the weirs, two water surface gages located upstream and downstream from each weir on the center line of canal, shown in Figure 7, were used to measure the head on the weir. Since Inlet No. 1 was located between the upstream weir and Gage No. 1, Inlet No. 1 was not used when the upstream weir was calibrated; instead, the flow was discharged into the canal from the head box or from both the head box and Inlet No. 2 located downstream. When the downstream weir was calibrated, part of the flow was passed into the canal through the head box and part through the inlets.

The different drainage flow entrance conditions for the two weirs might have accounted for some of the difference in the results of the calibrations; however, it is believed that the chief cause for the difference was the automatic control gate at the downstream end of the model. The gate may have changed flow currents in the vicinity of the downstream weir, and it may have backed the water surface up in the canal to produce erroneous water surface gage readings downstream from the downstream weir. For this reason it is believed that the calibration of the upstream weir is more reliable for general use; however, both are presented here.

The calibration data, obtained from tests shown in Figures 13, 14, and 15, are plotted in Figure 16. The efficiency of the weirs is indicated by the coefficient of discharge curves shown in Figure 16. Discharge coefficients were determined from the equation.

$$Q = CLH^{3/2}$$

where

Q is the total discharge over the weir,

H is the head on the weir determined by averaging the two water depths upstream and downstream from the weir and subtracting the weir height above the canal bottom, and

L is the length of the weir crest plus one-half of the length of the submerged end slopes (weir length plus 10H).

The data indicate that both the 51-foot upstream weir and the 102-foot upstream weir were more efficient when the drainage flow entered the canal downstream from the weir. Also, if all the downstream weir data are disregarded as suggested above, the coefficient curves indicate that longer weirs are less efficient than short ones.

The coefficient curves also indicate that the 51-foot weir is more efficient for small heads than for large heads. This cannot be explained, but is quite possible considering the unusual circumstances under which these weirs were calibrated. To produce the 51-foot weir the downstream half of the weir was covered. The downstream water surface gage was, therefore, 51 feet farther from the weir than in the case of the 102-foot weir. This might have affected the head measurement in such a manner as to produce the coefficient curves shown in Figure 16. Too, the coefficient "C" is very sensitive to small discrepancies in head measurement because the head is extremely small. The 51-foot weir was approximately 4 feet long in the model whereas the head on the weir was only a fraction of an inch. If the head measurement is in error by 0.01 of an inch in the model (equivalent to 0.01 of a foot in the prototype) the coefficient will be changed 0.1 to 0.2 in value, depending upon whether the total head in the prototype is 1 foot or 3 inches. Similar effects at scale heads would not be present in the prototype, only at the same absolute head.

The data showed the depth of flow to be greater downstream from the weir than upstream. This is believed to be a normal condition for velocities below critical. The depth difference was more pronounced at the downstream weir, however, which provided further evidence that the control gate at the downstream end of the model might be contributing to the higher water surface measured downstream from the downstream weir.

The curves in Figure 16 are recomputed in Figure 17 using only the head determined at the upstream gage. The discharge coefficients are greater because the depth of flow upstream of the weir is less than downstream. For example, when the average of the upstream and downstream gages is used for the 107-foot weir in Figure 16, a head of 0.5 foot on the weir gives a coefficient of 2.76. When only the upstream gage is used for the same weir the coefficient for 0.5 foot of head is 3.53, Figure 17.

<u>Inlet location affects weir efficiency</u>. A weir was found to be more efficient if the drainage flow entered the canal downstream rather than upstream from the weir. This was proved by the study of discharge coefficients in the preceding section, and is indicated in this section by the percentage of drainage inflow that the weir will discharge, Figure 18, and by a specific application in Figure 19.

In computing the percent of drainage inflow that the weir or weirs will discharge when the canal is discharging its normal flow of 200 second-feet, the first 20 second-feet of drainage inflow was not considered since it is needed to bring the water surface elevation in the canal up to weir crest elevation. The weir crests are 4.802 feet above the canal bottom at which depth the canal is expected to discharge 220 second-feet, Figure 9. The efficiency of a weir or weirs then, in this report, is also expressed by the percentage of total drainage flow in excess of 20 second-feet that a weir (or weirs) will discharge.

The data shown in Figure 18 indicates that when the drainage flow entered the canal upstream from a weir, the weir discharges about 74 percent of the inflow above 220 second-feet. When the drainage inflow entered the canal downstream from the weir, the weir discharge increased approximately 10 percent to about 84 percent. If the weir is located between two inlets so that one-half of the excess flow enters at an inlet upstream from the weir and one-half at an inlet downstream, the weir then discharges about 80 percent of the excess over 220 second-feet.

The reasons for the variations in weir outflow were readily apparent in the model. When drainage water enters the canal through an inlet downstream from the weir, the inflow produces a backwater effect which reduces the velocity of flow in the canal upstream and raises the water surface elevation so that more water spills over the weir. It is reasonable to assume that because the inflow enters at right angles to the canal rather than at an angle pointing downstream, the effect is appreciable. The weir would probably discharge even more water if the inflow entered the canal in an upstream direction. The distance between inlet and weir would probably also effect the weir discharge; if the inlet is close to the weir, the weir would discharge more than if the inlet is farther downstream because the depth of flow in the canal would be deeper near the source of the inflow.

Since the capacity of a weir is indicated by these tests to be greater when it is upstream of the inlet rather than downstream additional test data, shown in Figure 14 and plotted in Figure 19, were taken to determine how much the capacity of the 163-foot long weir at Station 360+00 (not included in the model) could be increased by relocating it upstream of the inlet at Station 358+95 and whether the flow depth in the canal could thereby be reduced.

The model head box, the upstream weir, and the two adjacent inlets all shown in Figure 5 were used to supply this test data. The downstream model weir was closed. The head box was used to supply the normal canal flow of 200 second-feet plus the design drainage flow of 52 second-feet from the upstream inlet at Station 305+55. Model Inlet No. 1 or Model Inlet No. 2, was used to supply the design drainage flow of 273 second-feet from the inlet at Station 358+95, depending upon whether the weir was at the preliminary location or relocated upstream of the inlet. The weir was tested at half length and full length in order that the data could be used to extend the curves in Figure 19 to and beyond the 163-foot length of weir.

The discharge curves in Figure 19 at Points "A" and "B" show that the 163-foot weir will discharge approximately 30 second-feet more water when the weir is located upstream of the inlet at Station 358+95. The depth of flow curves at Points "C" and "D" in Figure 19 show that the water surface is about 0.4 of a foot lower when the weir is relocated. It is, therefore, recommended that the weir at Station 360+00 in the preliminary design be relocated upstream from the inlet at Station 358+95.

Efficiency of two weirs. The efficiency of two weirs discharging simultaneously was determined in the model. The two weirs reproduced in the model, Figure 7, were located at Stations 456+10 and 460+90, Figure 8.

In determining the efficiency of the two model weirs the three adjacent inlets were considered to be discharging into the canal. Two of the three inlets were reproduced in the model while the upstream inlet at

Station 450+20 was not. The 85 second-feet design discharge from this inlet was introduced into the canal through the head box along with the normal canal discharge of 200 second-feet. The design discharges of the two inlets reproduced in the model were 115 second-feet for the inlet at Station 455+25 and 210 second-feet for the inlet at Station 458+20.

When all three inlets are discharging their design capacities into the canal, Run No. 1 in Figure 20, the two weirs discharge about 88 percent of the total drainage inflow in excess of 20 second-feet, as shown in Figure 21 for 410 second-feet. In other words, when 410 second-feet of drainage water enters the canal about 88 percent of 390 second-feet, or 343 second-feet, is discharged by the weirs. Twelve percent or 67 second-feet remains in the canal along with the 220 second-feet. Of this 88 percent the upstream weir discharges about 64 percent of 343 second-feet or 251 second-feet while the downstream weir discharges 24 percent or about 92 second-feet, shown in Figure 22 at Points "A" and "B," respectively.

For smaller drainage flows into the canal, the efficiency of the overflow weirs is greater than 88 percent, as shown in Figure 21. The total flow over both weirs and the division of flow between the two weirs may be obtained from Figure 22.

Efficiency of weir modifications. Modifications were made to the weirs to determine the effect of crest length and number of weirs on the total weir discharge and on distribution of discharge between the two weirs, Figure 22. The weirs were modified by shortening one or the other of the two weirs, or both, to one-half the preliminary length or by eliminating one of the weirs.

Shortening the upstream weir to one-half of its preliminary length reduces its discharge but increases the discharge of the downstream weir. This provides more equal distribution of the flow between the two weirs than was obtained in the preliminary design; however, the total flow discharged by the two is then reduced. If the downstream weir is shortened instead of the upstream weir, the downstream weir discharge is decreased while that of the upstream weir is increased; but again, the total discharge is reduced. Eliminating the half weir entirely further increases the discharge of the one remaining full length weir, but its discharge is less than the total discharge including the half length weir. Therefore, it can be concluded that shortening or eliminating a weir will increase considerably the discharge of other weirs either upstream or down, but the total discharge of the remaining weirs is less than the former total discharge.

If both weirs are reduced to one-half of their preliminary length, the total discharge by the two weirs is reduced. However, the discharge of the two half-length weirs is more than either one of the full length weirs can discharge operating alone. Therefore, it can be said that two half-length weirs spaced some distance apart with an inlet in between are better than one full-length weir placed either upstream or downstream.

Efficiency of the preliminary prototype system of weirs and inlets. The efficiency of the complete prototype system of weirs in discharging the maximum anticipated drainage inflow was estimated using the model data thus far presented in this report. The efficiency of the entire system between Stations 305+25 and 460+90, Figure 8, was analyzed in two ways for the severest operating condition, in which all inlets are discharging their design capacities into the canal simultaneously.

The first analysis was made at the time of the model study while the second analysis was made after a thorough study and evaluation of all the data obtained. The latter analysis provides a more favorable estimated flow condition in the canal than does the first analysis. It is believed that the second analysis provides the truest estimate of prototype conditions.

First analysis.--In the first analysis, Figure 23, the discharge was estimated for each individual weir by assuming that the upstream model weir, without the inlets or weir downstream operating, represented each individual weir in the prototype system. For example, beginning at the upstream end of the canal, the first two drainage inlets encountered are designed to discharge 52 and 273 second-feet of drainage water into the canal, respectively. The total drainage inflow upstream of the first weir then is 325 second-feet. From the dashed-lined curve in Figure 18 the first weir is estimated to discharge 220 second-feet which would leave 305 second-feet in the canal downstream from the first weir located at Station 360+00. The next two inlets encountered before arriving at the next weir are designed to discharge 87 and 138 second-feet of drainage flow into the canal. This added to 305 second-feet makes 530 second-feet in the canal, 330 of which can be considered as drainage inflow since the normal flow in the canal is 200 second-feet. From Figure 18 the next weir at Station 436+25 is estimated to discharge 225 second-feet. The same procedure is followed for the remainder of the weirs and inlets downstream.

The estimated weir discharges in this analysis were made without correction for the variations in weir lengths and were taken from Figure 18 which is for a weir 102 feet long. Only one of the four weirs was of this length while the other three lengths were 163, 113, and 107 feet. Therefore, the three longer weirs will discharge more than estimated. Also, because the prototype weirs were located on or near the outside curvature of the canal bends, the prototype weirs should discharge more than indicated by the model which was constructed in a straight line.

The analysis indicates that about 295 second-feet of flow will remain in the canal downstream from the last weir. A siphon having a design capacity of 100 second-feet is provided in the canal downstream at

Station 585+00 to discharge the flow from the canal that exceeds 200 second-feet. Since the estimated excess flow of 95 second-feet is believed to be higher than will occur in the prototype and is less than 100 second-feet, the preliminary weir system is satisfactory in that it will discharge a sufficient quantity of the total drainage flow. However, at some points along the canal between weirs and upstream of the first weir, the quantity of water in the canal may be sufficient to overtop the canal banks, particularly at the canal bends. The analysis indicates that the canal will be required to discharge over 500 second-feet at four different places along the canal.

According to Figure 9, uniform flows exceeding 450 second-feet will overtop the canal banks 6.8 feet high. However, the data in Figures 14, 15, 16, and 20 indicate that the canal will flow at less than uniform flow depth in the four reaches of canal in which more than 500 second-feet is flowing because these reaches are downstream from the inlets where the velocity is faster than for uniform flow. The data also indicate that the deepest flow will be upstream of the inlets but will still be less than the uniform flow depth of the maximum discharge which occurs downstream from the inlets. For example, in Run No. 1, Test No. 11, Figure 20, the canal discharge downstream of Inlet No. 2 is 360 second-feet and the depth of flow is 5.28 feet which is less than the uniform flow depth 6.1 feet for 360 second-feet. However, upstream of the inlet the canal discharge is only 150 second-feet, but the depth of flow is 5.7 feet which is more than the uniform flow depth of 3.9 feet for 150 second-feet, but less than the uniform flow depth of 6.1 feet for 360 second-feet. Other examples from the data in Figures 13, 14, 15, and 20 show the same trends. Therefore, maximum flow depths in the canal will probably occur upstream of the inlets and will be less than the uniform flow depth for the maximum flow which occurs downstream of the inlet. Since the maximum estimated discharge upstream from any inlet is 305 second-feet and 530 second-feet downstream from any inlet, Figure 23, the estimated maximum depth of flow is less than the uniform flow depth of 7.2 feet for 530 second-feet, but more than the uniform flow depth of 5.6 feet for 305 second-feet, Figure 9. Therefore, the flow would probably overtop the 6.8 feet high canal banks at locations upstream from an inlet.

It is believed that the calculated depth of flow in the prototype will be affected but very little if canal velocities are either faster or slower than indicated in the model because flow conditions at the weirs will act as a compensating factor. For example, if the flow in the prototype between weirs and inlets is faster than in the model the weir discharges will be less, these two factors will tend to compensate each other in establishing the flow depth. The same type of compensation will occur if the flow in the prototype is slower than in the model.

Second analysis.--The second analysis utilizes data from Figure 20 that is plotted in Figure 24. As in the first analysis the upstream weir in the model is assumed to represent each weir in the prototype system, but the discharges are taken from the curve of Figure 24 which was obtained with the inlet and weir downstream discharging as well as the inlets upstream from the weir.

The second analysis is shown in Figure 24 and was made as follows. Beginning at the upstream end of the canal the first two inlets discharge 52 and 273 second-feet of drainage water into the canal, respectively, upstream of the first weir. Two inlets downstream from the first weir are designed to discharge 87 and 138 second-feet of drainage water, respectively, into the canal. The total drainage inflow upstream and downstream of the weir then is 550 second-feet. From Figure 24 the first weir at Station 260+00 is estimated to discharge 340 second-feet which would leave 185 second-feet of flow in the canal downstream from the first weir. Proceeding now to the second weir at Station 436+25, the drainage flow in the canal upstream of the weir can be considered to be the total drainage inflow of the two inlets downstream from the first weir and upstream of the second minus 15 second-feet, which is needed to increase the 185 second-feet already in the canal to the normal canal flow of 200 second-feet. The drainage flow in the canal upstream of the second weir then is 210 second-feet. The drainage inflow downstream from the second weir but upstream from the third weir is the sum of 85 and 115 second-feet from two drainage inlets, respectively, or is 200 second-feet. The sum of the drainage flow in the canal upstream and downstream of the second weir then is 410 second-feet, and from Figure 24 the estimated discharge of the weir is 250 second-feet. This same procedure in estimating weir discharges is followed proceeding downstream to the last weir. The discharge of the last weir is estimated from the dashed-lined curve in Figure 18 in the same way as in the first analysis since no inlets or weirs are operating downstream from the last weir. However, the siphon quite some distance downstream at Station 585+00 discharging drainage flow from the canal would probably reduce slightly the estimated discharge of the last weir.

Even this refined analysis is an approximation for the following reasons. The model weir length cannot represent each prototype weir length; the distances to inlets upstream and downstream and to the next weir downstream are not truly represented in each case; the proportion of discharge by inlets upstream in relation to discharge of the inlets and weir downstream is not the same in each case as in the model; the canal bends are not considered; and perhaps other discrepancies exist. Nevertheless, it is believed that these discrepancies are relatively minor in affecting the estimated flow depths in the canal and the estimated quantity of water each weir discharges, and it is believed that the general flow pattern of drainage flow into and out of the canal is well represented by this second analysis. To improve on the second analysis it would have been necessary to construct three weirs in the model, one upstream of the representative weir as well as one downstream, so that the representative weir would have been bracketed by a weir upstream and downstream as well as by inlets both upstream and downstream.

The second analysis indicates that the flow depth in certain reaches of the canal is critical, but that the total quantity of water that the weirs will discharge is sufficient with respect to the capacity of the siphon downstream. The critical reaches in which the deepest flow will occur are the same as found in the first analysis; but, in general, depths are not estimated to be as critical. The reach of canal having the greatest flow depth is believed to be upstream of the inlet at Station 358+95 where 273 second-feet enters the canal. At this inlet there is already 252 second-feet in the canal. An additional 273 second-feet entering the canal at right angles to the direction of flow will create a backwater effect upstream from the inlet that will approach the uniform flow depth of the total discharge downstream from the inlet, as discussed in the first analysis. The total discharge downstream from the inlet is 525 second-feet, therefore, the expected maximum flow depth which will occur upstream from the inlet would be less than the uniform flow depth of 7.1 feet for 525 second-feet, but more than the uniform flow depth of 5.1 feet for 252 second-feet, Figure 9. Since the canal banks are 6.8 feet high, the flow might overtop them, particularly at the bends.

The next most critical reach of canal is upstream from the inlet at Station 413+00, Figure 25. Here the maximum depth of flow would be expected to approach the uniform flow depth of 6.5 feet for 410 second-feet, Figure 9.

Efficiency of recommended prototype system of weirs and inlets. As a result of the two analyses, it is reasonable to expect that the weirs as preliminarily designed will discharge a sufficient quantity of the total drainage inflow, but that the flow depth upstream of the inlets might overtop the canal banks. To reduce the possiblity of flow depths reaching the top of the canal banks, two overflow weirs, one at Station 412+24 and one at Station 451+26, shown in Figures 1 and 4, were added to the preliminary layout. Station 412+24 was chosen for one of the weirs primarily to reduce the water surface upstream of the inlets at Stations 413+00 and 435+00. Station 451+26 was chosen for the other weir location primarily to reduce the water surface elevations upstream of the inlets at Stations 450+20 and 455+25. The exact locations of these weirs were chosen so as to discharge into natural ravines on the left hand side of the canal. No weir was added upstream of the inlets at Stations 305+55 and 358+95, instead the weir at Station 360+00 was relocated to Station 356+92 upstream of the inlet at Station 358+95 as is recommended and discussed on page 8. The last weir at Station 460+03 was also relocated to Station 460+90, but not as a result of this model study. With the two additional weirs at

Stations 412+24 and 451+26 and the weir at Station 360+00 relocated to Station 356+92, and drainage inflow and outflow is analyzed, as shown in Figure 26, in the same manner as the second analysis for the preliminary weir arrangement, Figure 25.

This analysis of the recommended weir arrangement indicates that the total discharge by the weirs is increased only 10 second-feet so that an estimated 245 second-feet will remain in the canal downstream from the last overflow weir. However, the estimated discharge remaining in the canal at any intermediate point does not exceed 335 second-feet as compared to 525 second-feet in the preliminary design; therefore, the flow depth upstream of the inlets will be reduced to something less than the uniform flow depth of 5.9 feet for 335 second-feet, Figure 9, as discussed in the first analysis of the preliminary design. Consequently, maximum flow depth which occurs upstream of an inlet is not likely to overtop the canal banks. The installation of the two additional weirs, and the relocation of the weir formerly at Station 360+00 to Station 356+92, is therefore recommended.

FIGURE 1
REPORT HYD. 407

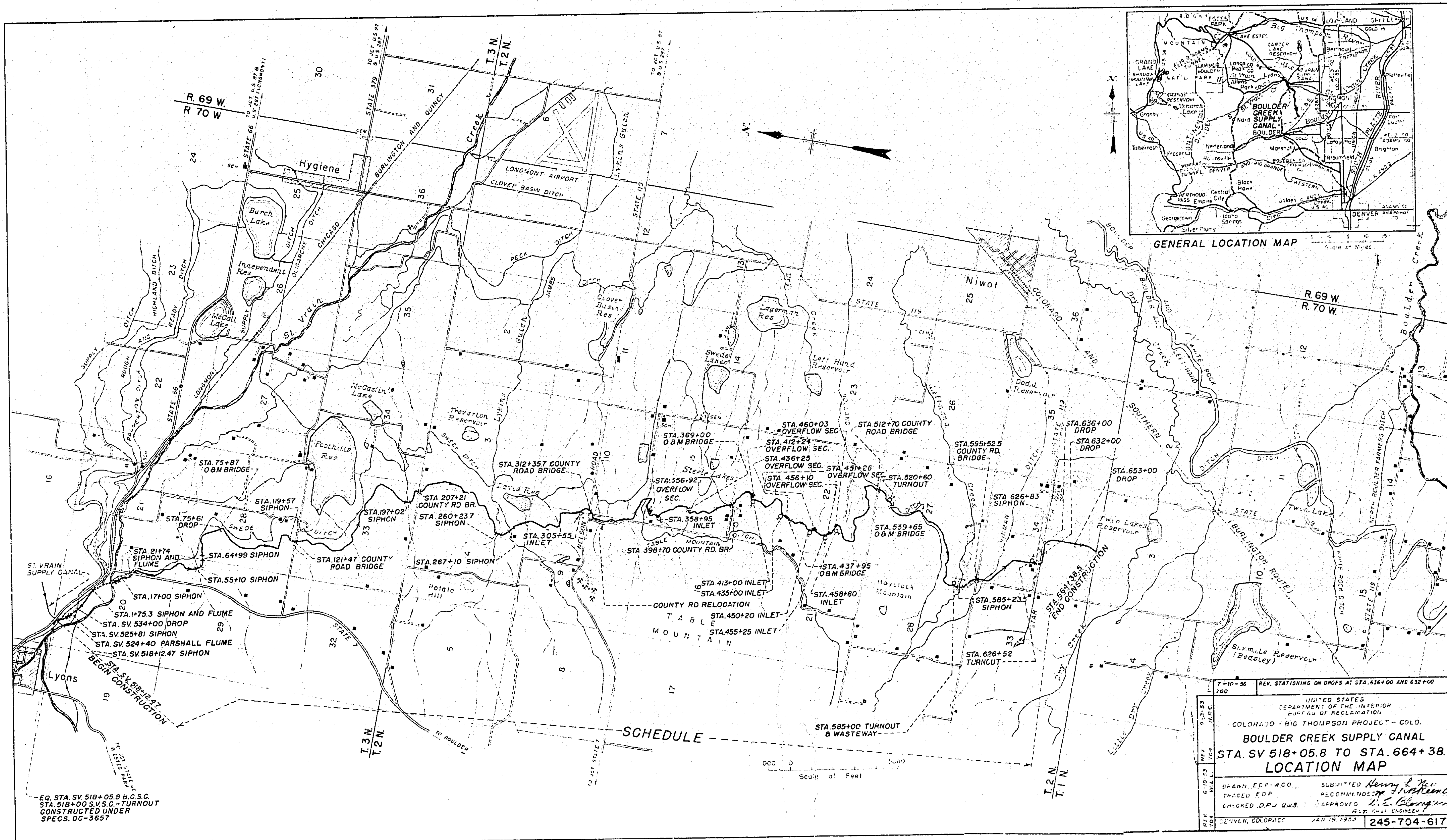
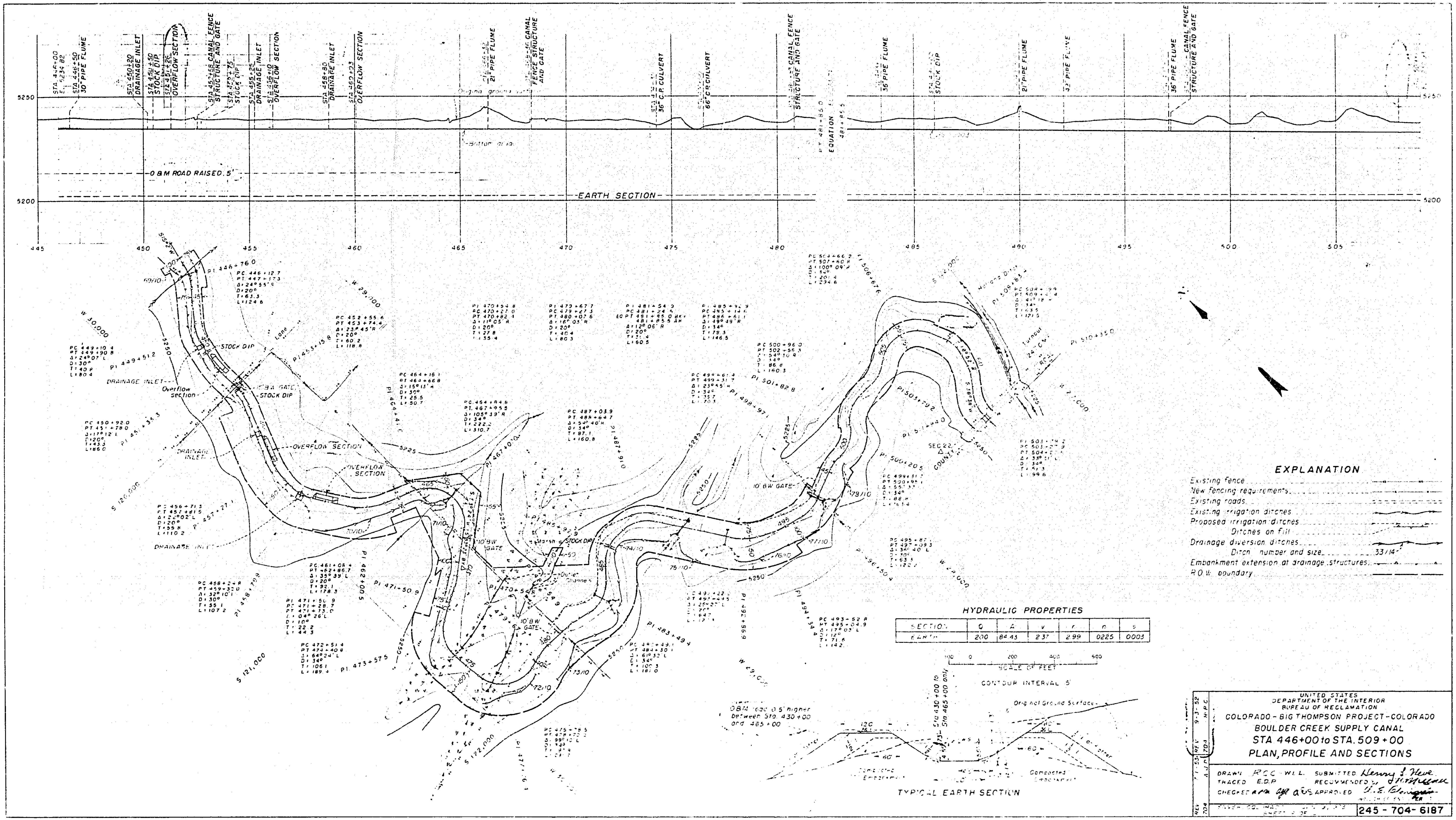
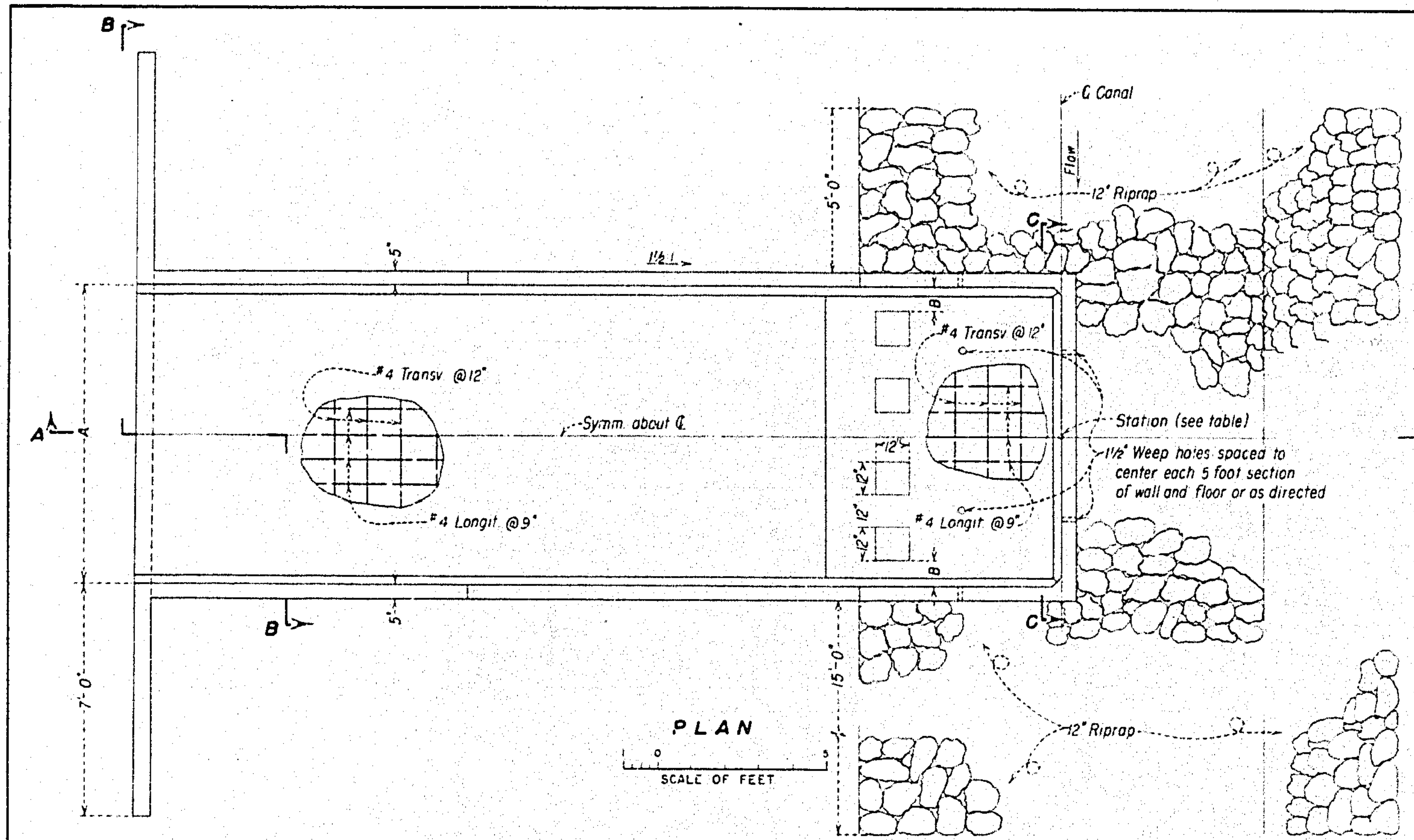
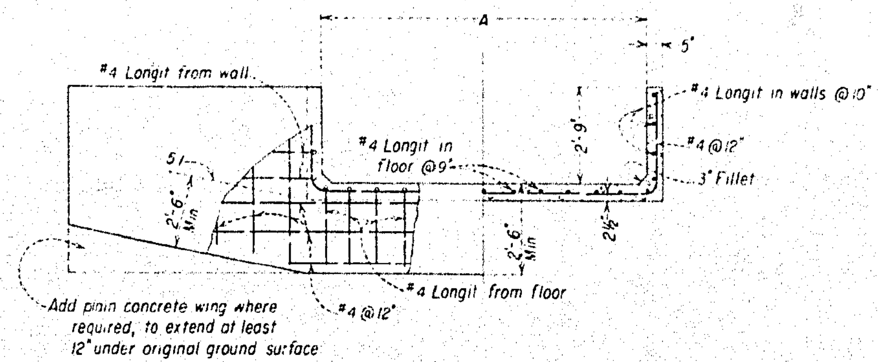


FIGURE 2
REPORT HYD. 407

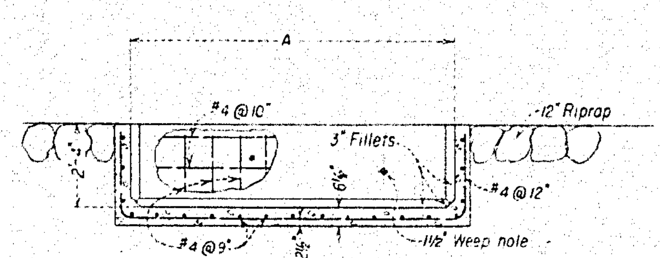




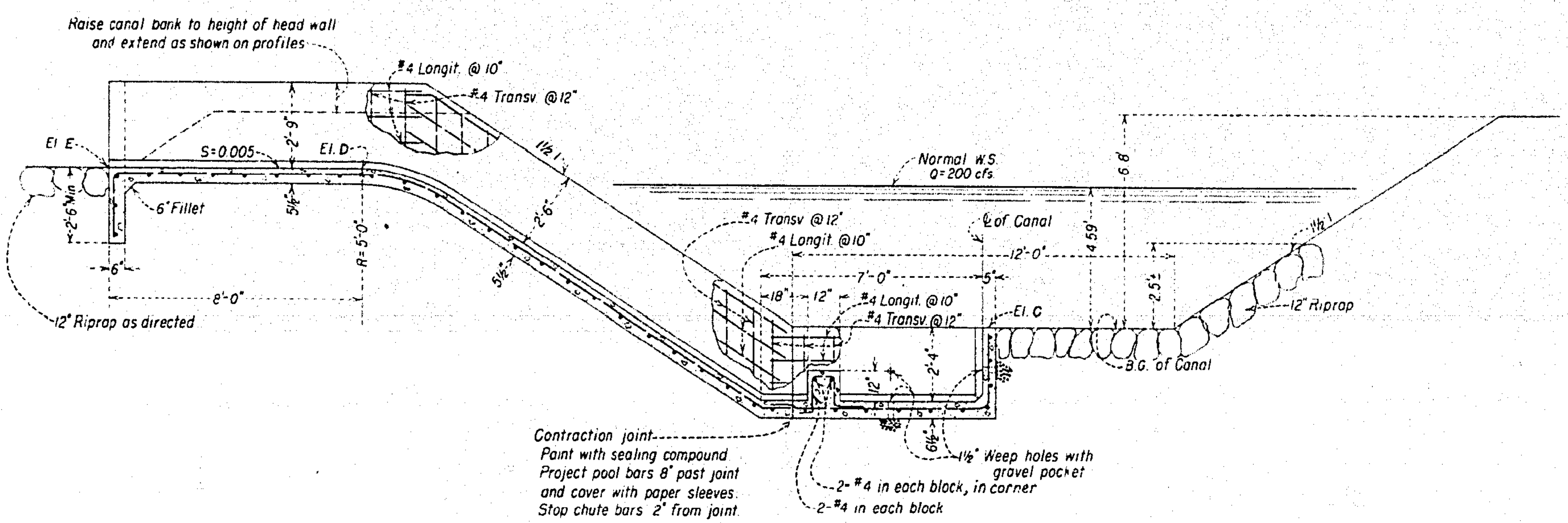
PLAN



SECTION B-B



SECTION C-C



SECTION A-A

ESTIMATED QUANTITIES

STATION	CONCRETE	REINF. STEEL
305+55	8.8 Cu Yds	710 Lbs
358+95	27.3 Cu Yds	2190 Lbs
413+00	11.8 Cu Yds	945 Lbs
435+00	16.5 Cu Yds	1330 Lbs
450+20	11.8 Cu Yds	945 Lbs
455+25	14.3 Cu Yds	1150 Lbs
458+80	22.2 Cu Yds	1780 Lbs

NOTES

Unless otherwise shown, place reinforcement so that the clear distance between face of concrete and nearest reinforcement is 1½", except provide a clear distance from face of concrete placed against earth or rock of 2".
Lap all bars 20 diameters at splices.
Thickness of concrete to vary uniformly between dimensions shown.
Base of entire structure to be placed on undisturbed earth or compacted fill.

STATION	Q	A	B	EL. C	EL. D	EL. E
305+55	52	7'-6"	15"	5239.05	5244.05	5244.09
356+95	273	36'-0"	6"	5237.45	5242.45	5242.49
413+00	87	12'-6"	9"	5235.82	5240.82	5240.86
435+00	138	20'-0"	6"	5235.16	5240.16	5240.20
450+20	85	12'-6"	9"	5234.69	5239.69	5239.73
455+25	115	16'-6"	9"	5234.54	5239.54	5239.58
458+80	210	30'-0"	6"	5234.44	5239.44	5239.48

SQUAD APPROVAL		
Civil		
Electrical	WB	2-18-53
Mechanical	C.A.B	2-18-53
Structural	GDP	2-18-53

THIS DRAWING SUPERSEDES UNREVISED DRAWING SAME NUMBER DATED JAN. 19, 1953

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

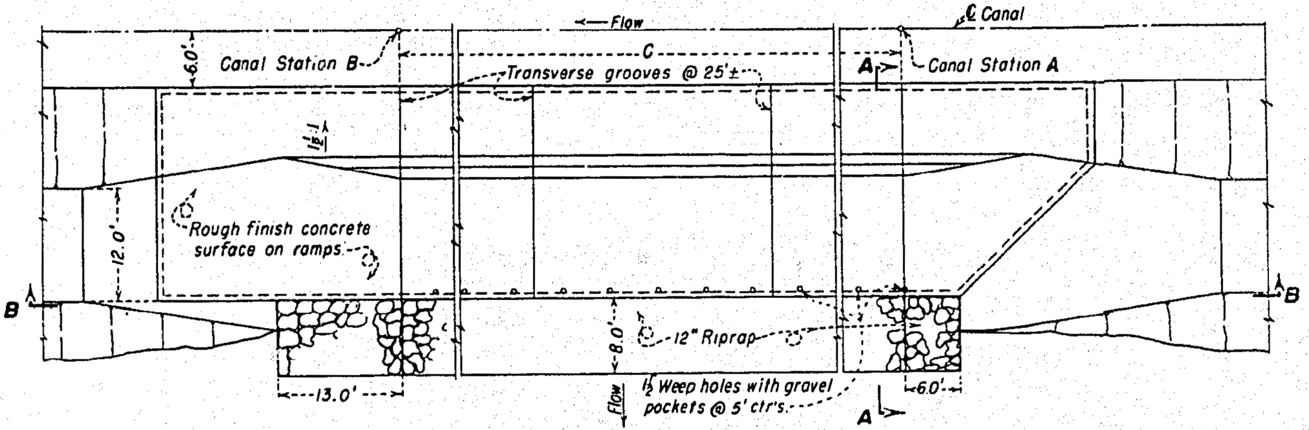
COLORADO - BIG THOMPSON PROJECT - COLO.

BOULDER CREEK SUPPLY CANAL

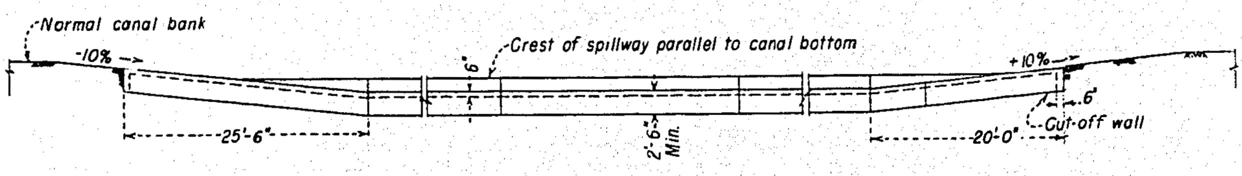
DRAINAGE INLETS

DRAWN R.C.R. SUBMITTED Henry L. Neve
TRACED C.J.S. RECOMMENDED T. Rippon
CHECKED G.E.M. APPROVED W.B. Keener
CHIEF DESIGNING ENGINEER
DENVER, COLORADO, JAN. 19, 1953
245-704-6214

REV 704 9-4-53 W.T.C.

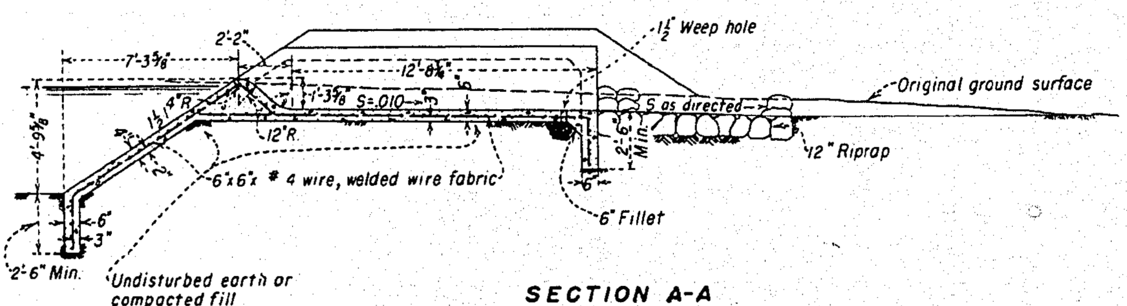


PLAN



ELEVATION B-B

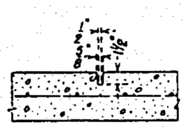
SCALE OF FEET



SECTION A-A

SCALE OF FEET

ESTIMATED QUANTITIES
(See table)



TRANSVERSE GROOVE DETAIL

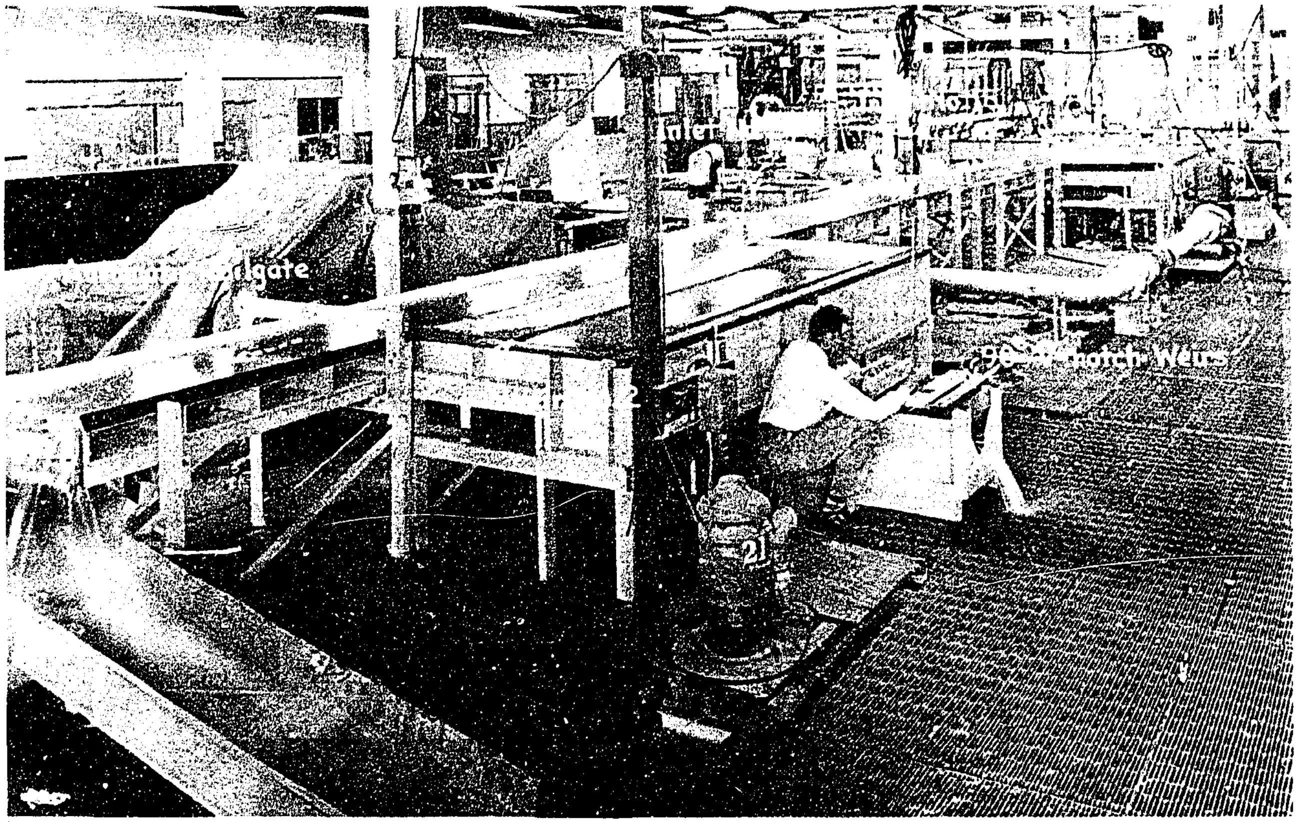
NOTE
Lap wire mesh reinforcement 6 inches at splices.
Fill transverse grooves with mastic joint filler.

LOCATION				ESTIMATED QUANTITIES	
STATION A	STATION B	EL.@STA.A	LENGTH C	CONCRETE	WIRE MESH REINF.
356+24	357+61	5237.53	137.0'	106 Cu. Yds.	3250 Lbs.
411+86	412+62	5235.85	76.0'	68 " "	2180 "
435+82	436+69	5235.12	87.0'	77 " "	2370 "
450+88	451+64	5234.67	76.0'	68 " "	2180 "
455+72	456+48	5234.53	76.0'	68 " "	2180 "
459+63	460+44	5234.41	81.0'	71 " "	2270 "

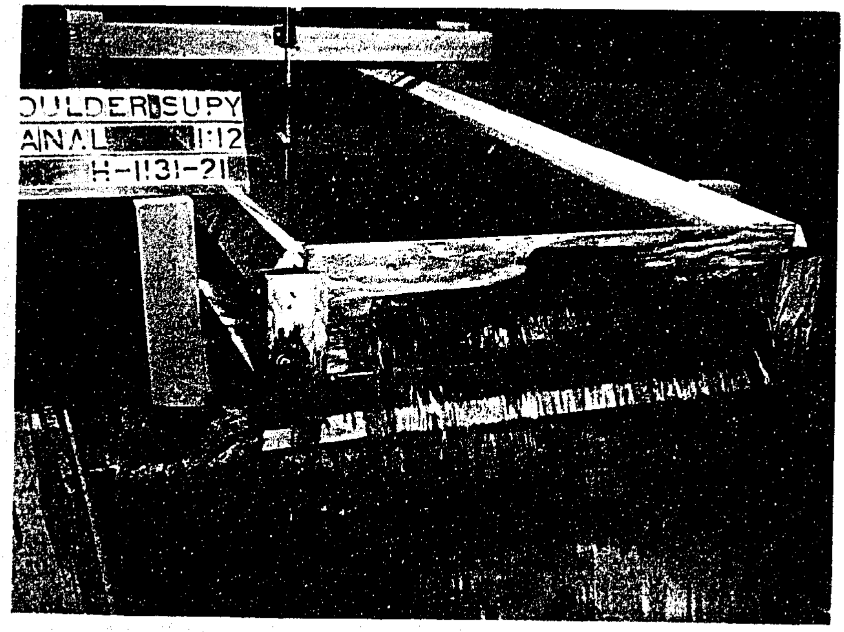
SQUAD APPROVAL		
Civil		
Electrical	WB	2-18-53
Mechanical	CAB	2-18-53
Structural	JHD	2-18-53

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO - BIG THOMPSON PROJECT - COLO.
BOULDER CREEK SUPPLY CANAL
OVERFLOW SECTIONS
LOCATION AND DETAILS

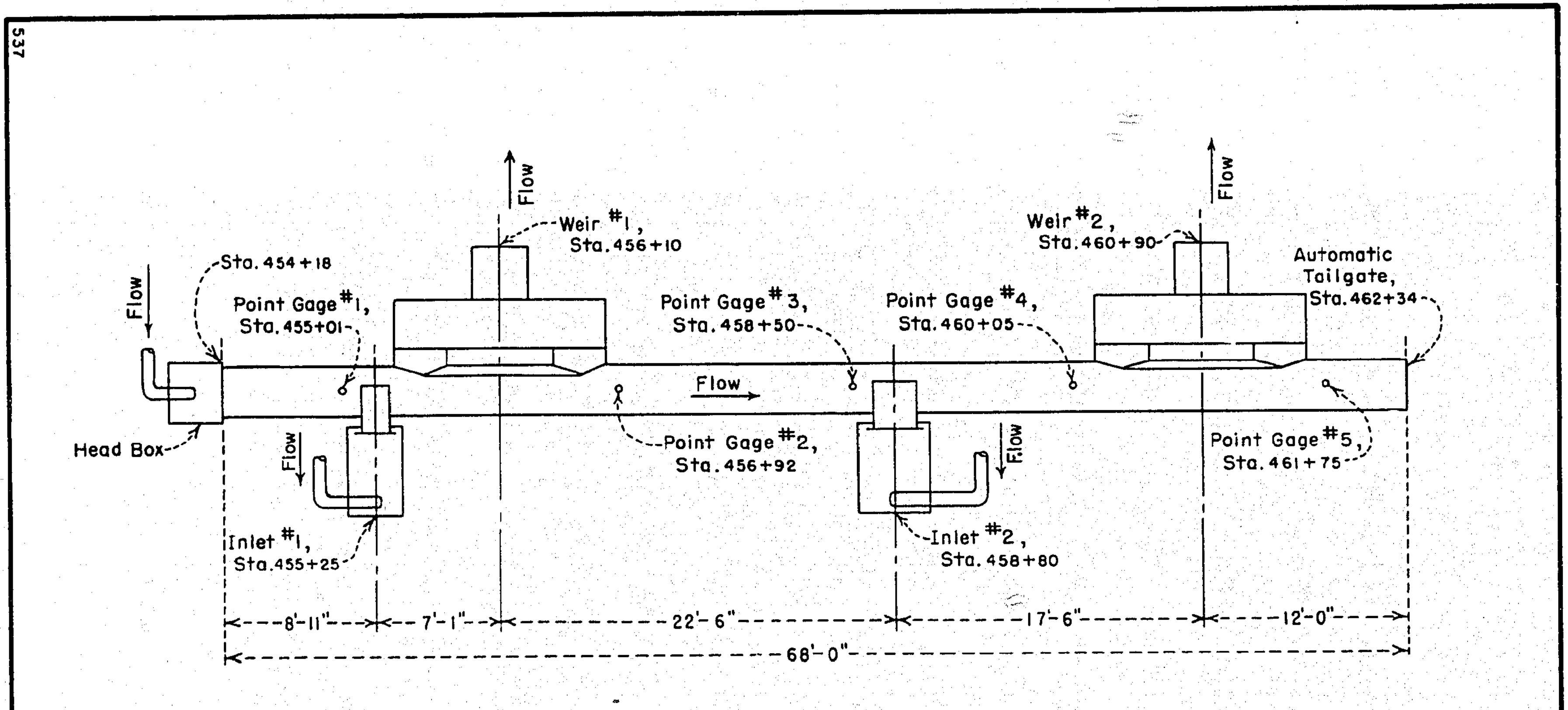
DRAWN J.E.M. SUBMITTED Henry L. Neve
TRACED C.J.S. (704) RECOMMENDED
CHECKED APPROVED
CHIEF DESIGNING ENGINEER
DENVER, COLORADO, JAN. 19, 1953
245-704-6215



BOULDER CREEK SUPPLY CANAL
GENERAL VIEW OF THE MODEL
1:12 SCALE MODEL



BOULDER CREEK SUPPLY CANAL
AUTOMATIC TAILGATE CONTROL
1:12 SCALE MODEL



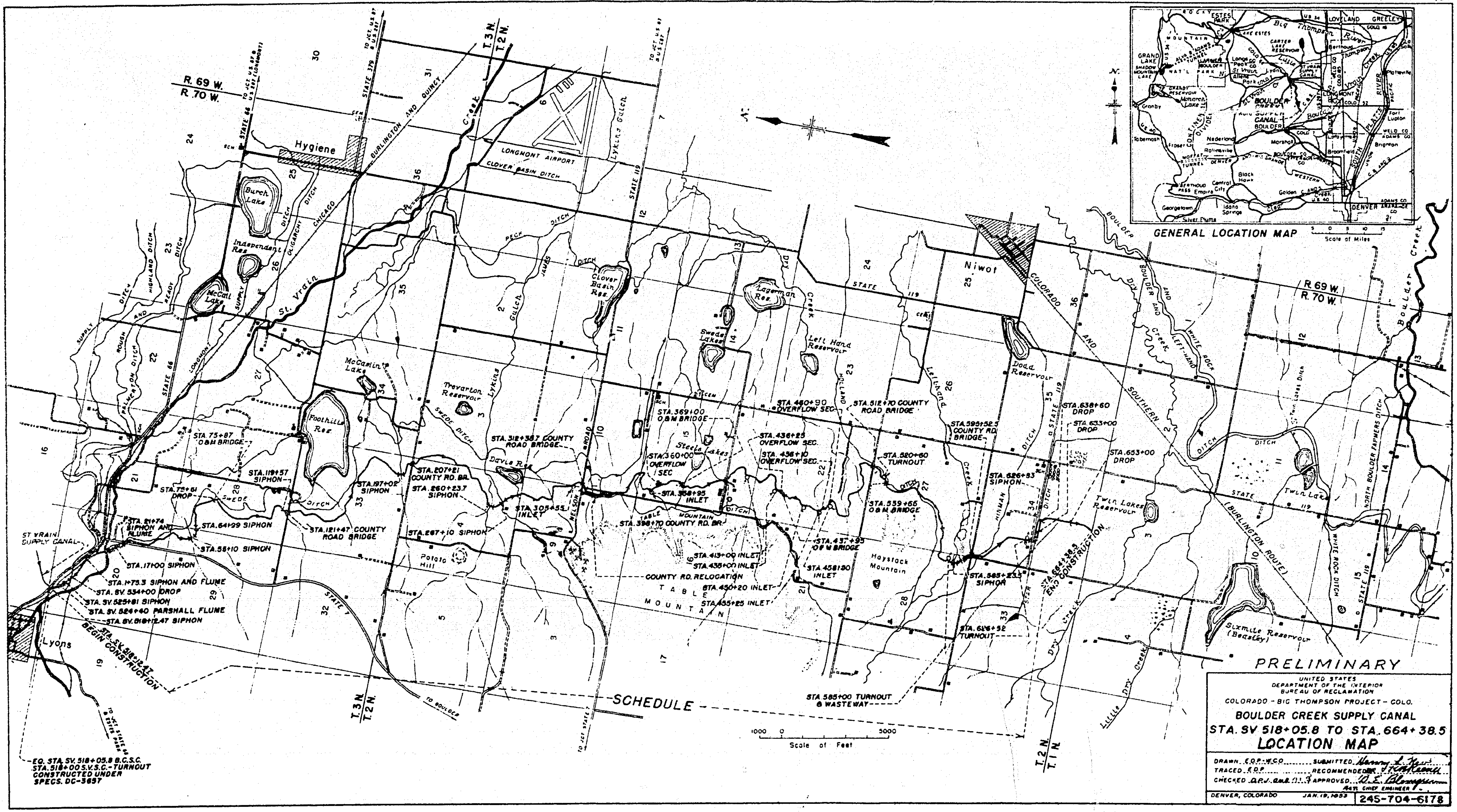
BOULDER CREEK SUPPLY CANAL

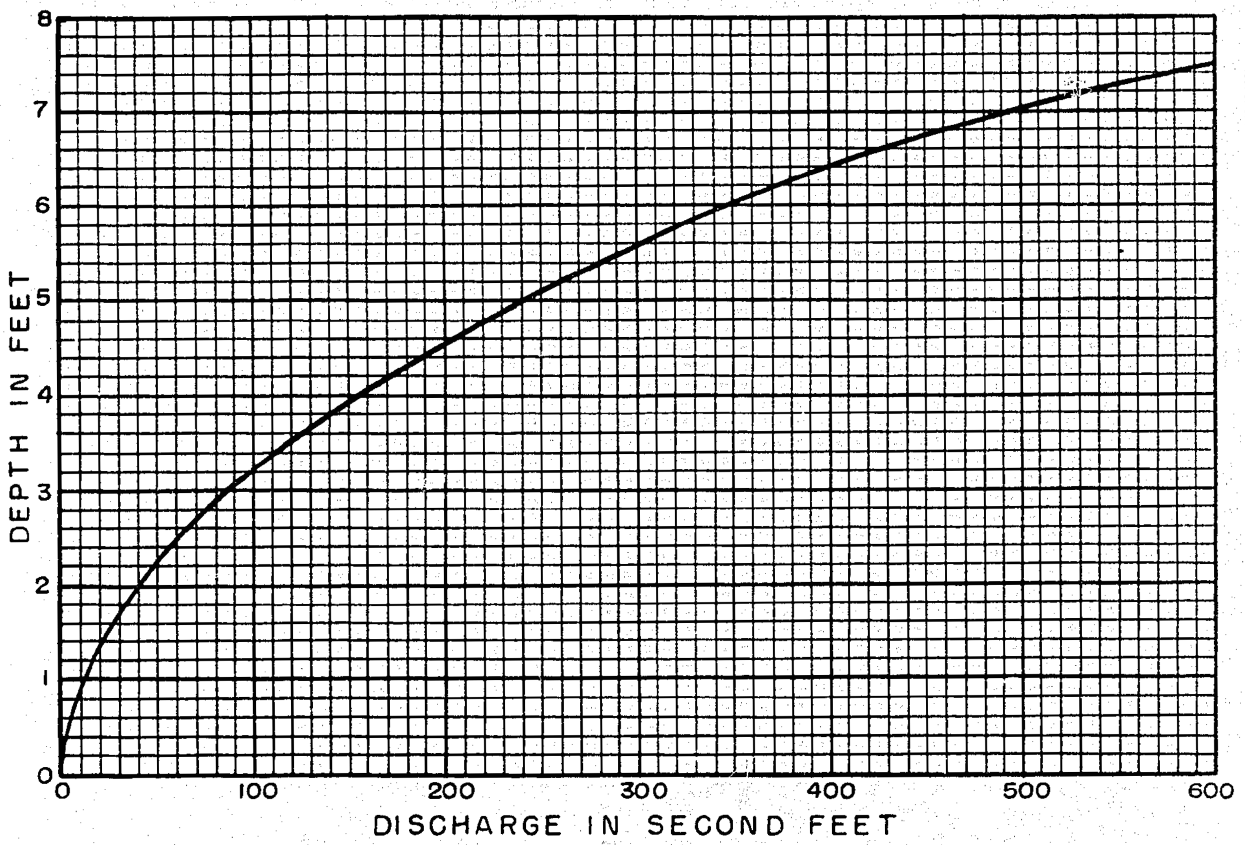
MODEL LAYOUT

1 : 12 SCALE MODEL

FIGURE 7
REPORT HYD. 407

FIGURE 8
REPORT HYD-407

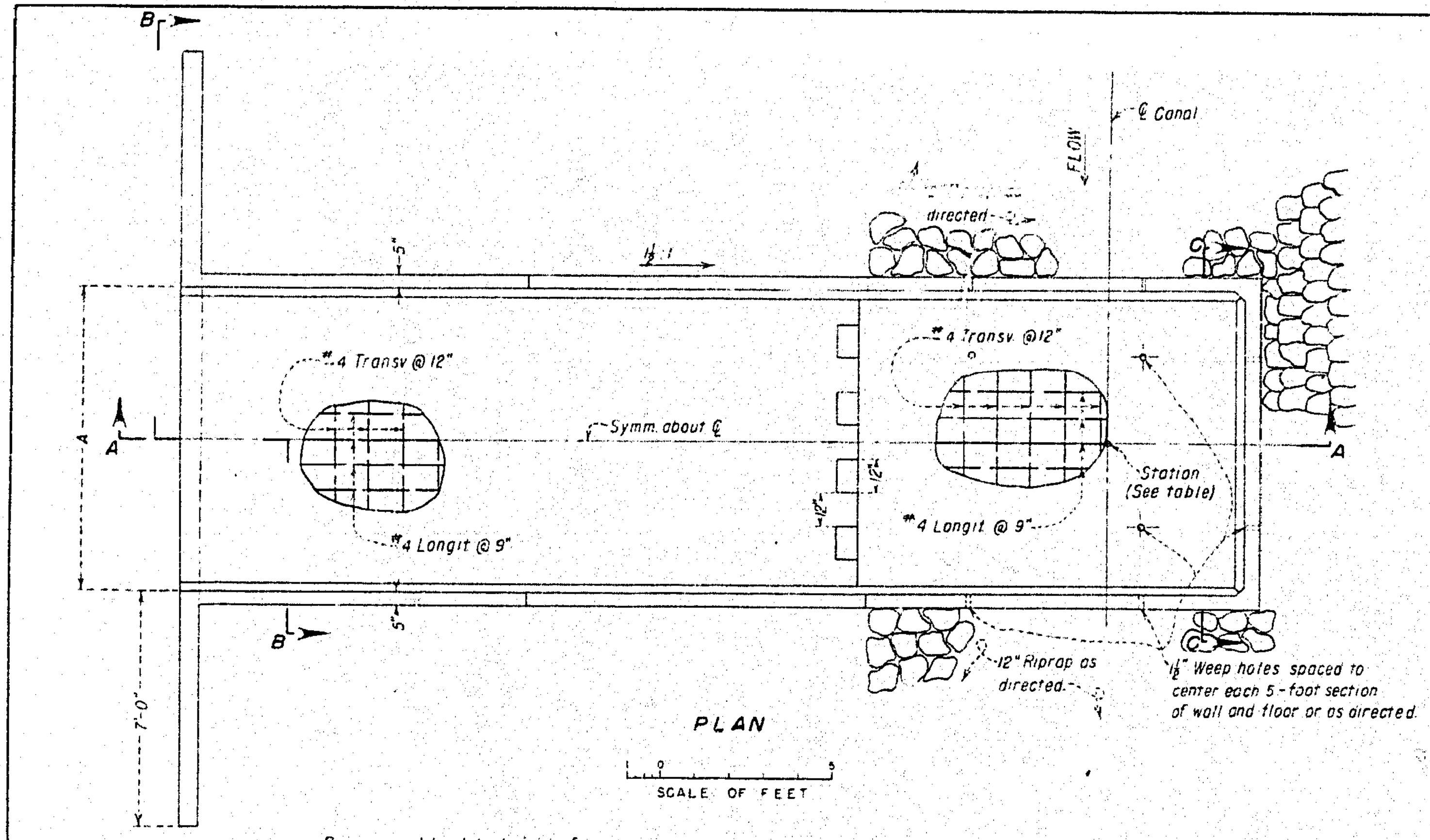




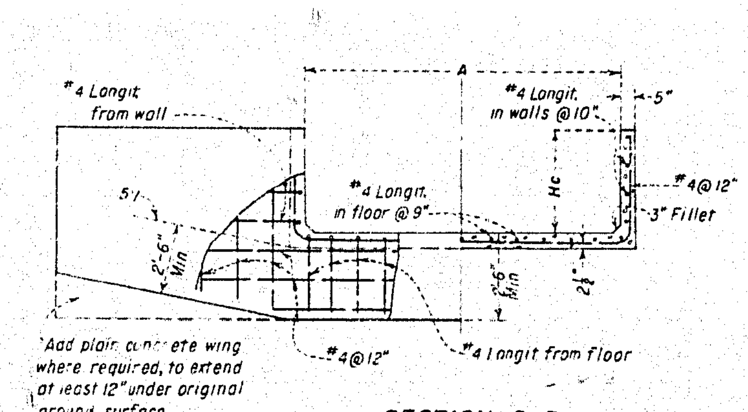
BOULDER CREEK SUPPLY CANAL

CANAL DISCHARGE CURVE—STA. 300+00 TO STA. 470+00

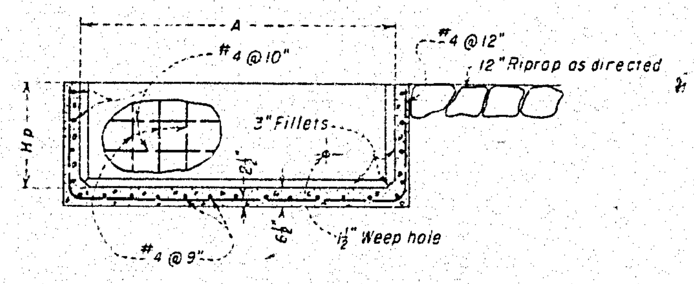
1:12 SCALE MODEL



PLAN



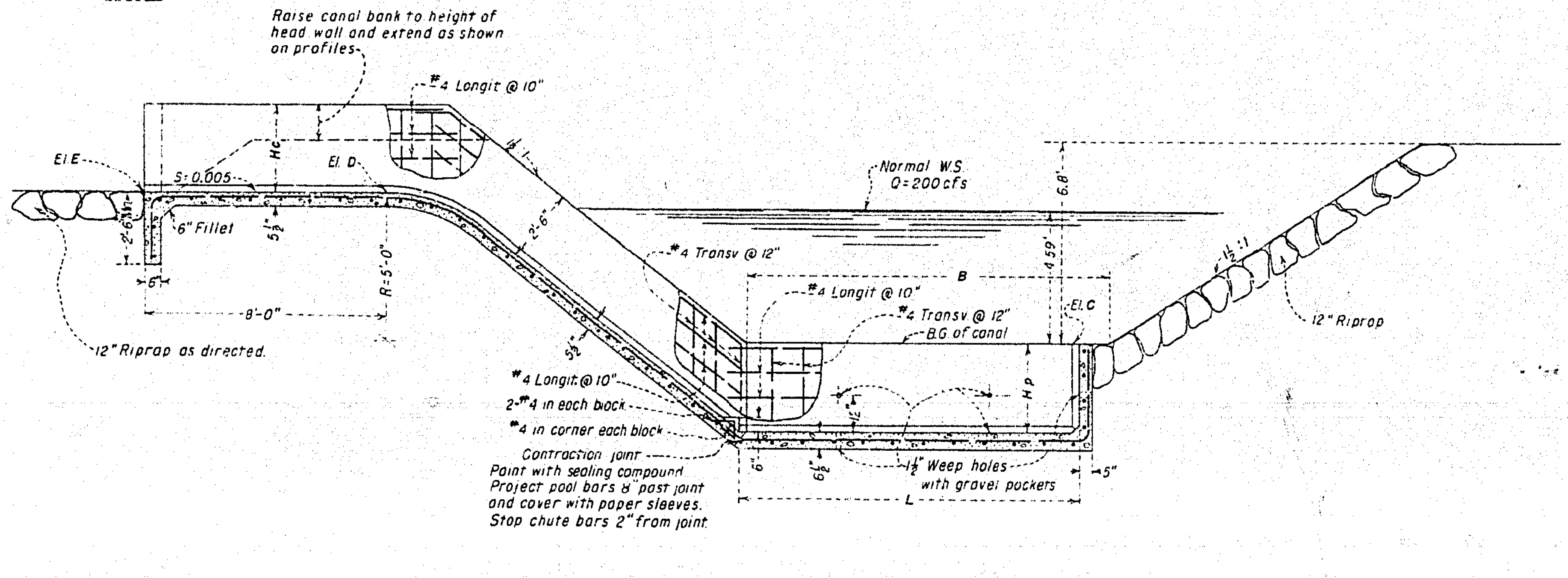
SECTION B-B



SECTION C-C

ESTIMATED QUANTITIES

STATION	CONCRETE	REINF STEEL
305+55	9.9 CuYds.	800 Lbs.
358+95	30.3 CuYds.	2430 Lbs
413+00	13.3 CuYds.	1065 Lbs
435+00	18.6 CuYds	1490 Lbs
450+20	13.3 CuYds	1065 Lbs
455+25	16.1 CuYds.	1290 Lbs
458+80	25.1 CuYds	2010 Lbs



SECTION A-A

STATION	Q	A	B	Hc	Hp	L	El. C	El. D	El. E
305+55	52	7'-6"	12.0'	2'-9"	2'-4"	11'-0"	5239.05	5244.05	5244.09
358+95	273	36'-0"	16.0'	2'-9"	2'-4"	11'-0"	5237.45	5242.45	5242.49
413+00	87	12'-6"	12.0'	2'-9"	2'-4"	11'-0"	5235.82	5240.82	5240.86
435+00	138	20'-0"	12.0'	2'-9"	2'-4"	11'-0"	5235.16	5240.16	5240.20
450+20	85	12'-6"	12.0'	2'-9"	2'-4"	11'-0"	5234.69	5239.69	5239.73
455+25	115	16'-6"	12.0'	2'-9"	2'-4"	11'-0"	5234.54	5239.54	5239.58
458+80	210	30'-0"	12.0'	2'-9"	2'-4	11'-0"	5234.44	5239.44	5239.48

NOTES

Unless otherwise shown, place reinforcement so that the clear distance between face of concrete and nearest reinforcement is 1½", except provide a clear distance from face of concrete placed against earth or rock of 2".
Lap all bars 20 diameters at splices.
Thickness of concrete to vary uniformly between dimensions shown
Base of entire structure to be placed on undisturbed earth or compacted fill.

PRELIMINARY

THIS DRAWING IS SUPERSEDED BY RETRACED DRAWING SAME NUMBER REVISED 9-4-53

SQUAD APPROVAL		
Civil		
Electrical	JAB	2-18-53
Mechanical	CMB	2-18-53
Structural	[illegible]	2-18-53

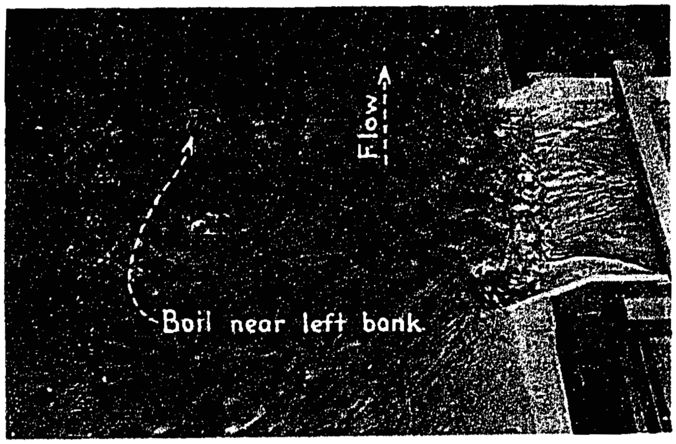
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO - BIG THOMPSON PROJECT - COLO.

BOULDER CREEK SUPPLY CANAL

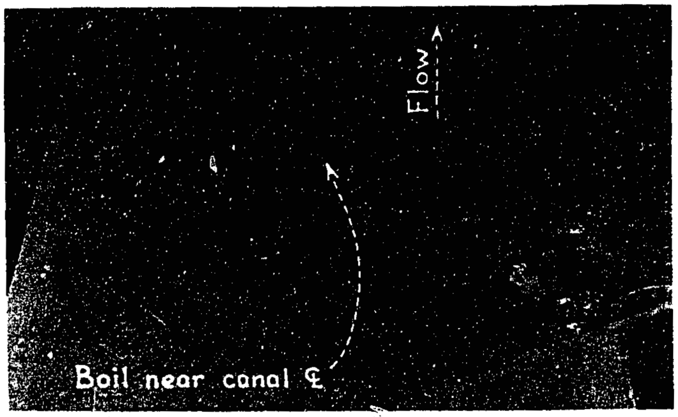
DRAINAGE INLETS

DRAWN R.C.R. SUBMITTED Henry L. Neve
TRACED T.J.M. (704) RECOMMENDED [illegible]
CHECKED [illegible] APPROVED [illegible] CHIEF DESIGNING ENGINEER
DENVER, COLORADO JAN. 19, 1953 245-704-6214

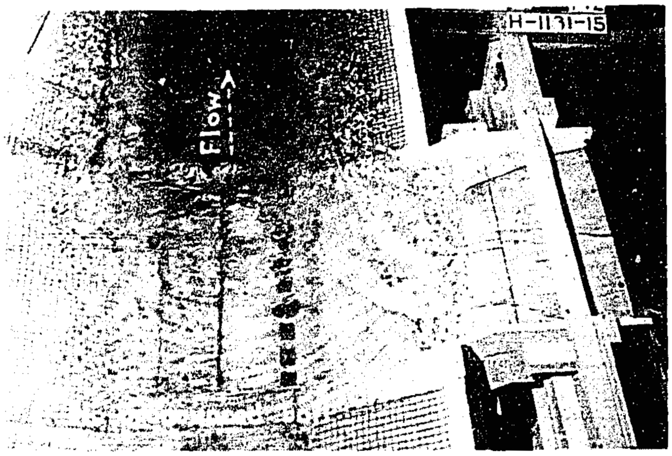
GPO 841653



A. Preliminary inlet. (See Figure 10)

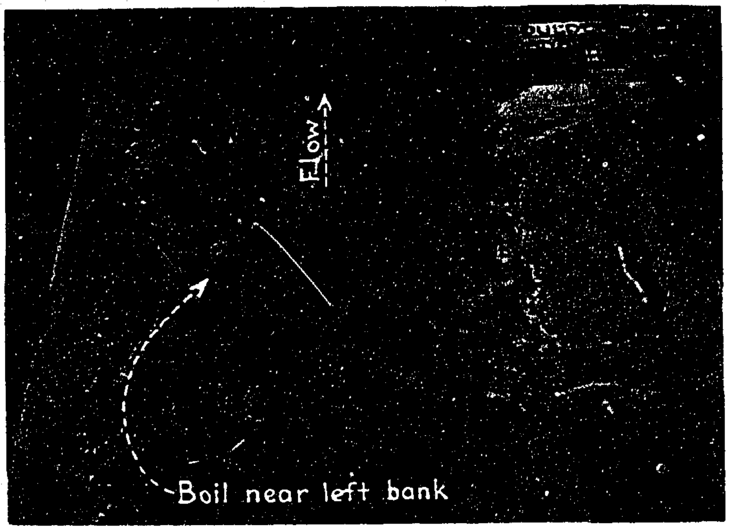


B. Chute blocks removed and the preliminary basin shortened to the center line of canal.

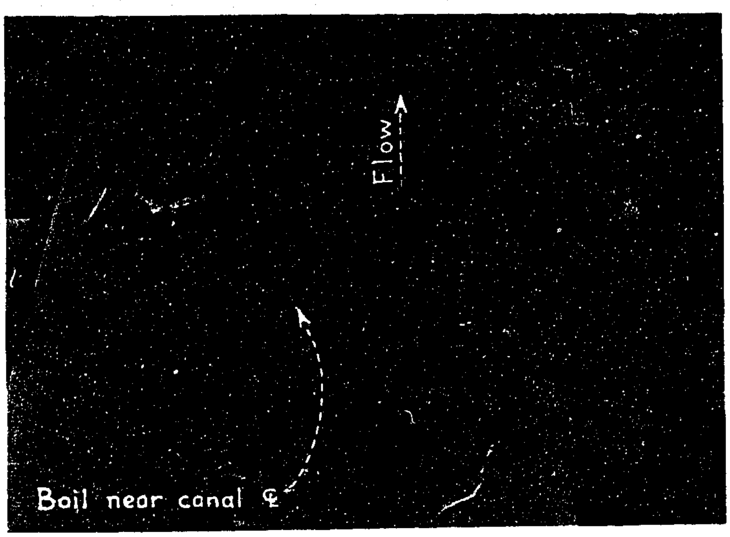


C. Recommended inlet - 1-foot baffle piers added to "B" above. (See Figure 3)

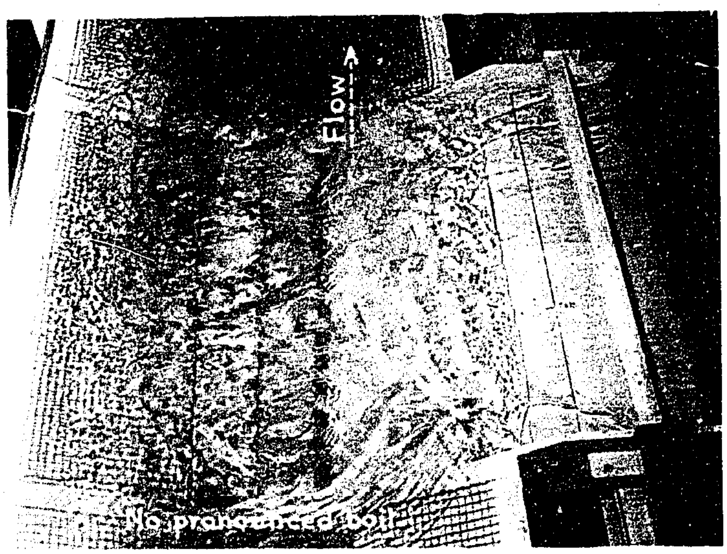
BOULDER CREEK SUPPLY CANAL
DRAINAGE INLET AT STA. 455+25
DISCHARGING THE DESIGN FLOW OF 115 SECOND FEET
1:12 SCALE MODEL



A. Preliminary inlet. (See Figure 10)



B. Chute blocks removed and the preliminary basin shortened to the center line of canal.



C. Recommended inlet - 1-foot baffle piers added to "B" above. (See Figure 3)

BOULDER CREEK SUPPLY CANAL
DRAINAGE INLET AT STA. 458+80
DISCHARGING THE DESIGN FLOW OF 210 SECOND FEET
1:12 SCALE MODEL

FIGURE 13
Report Hyd. 407

TEST NO. 13

NOTE: See figures 5 and 7 for Location Diagram

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TEST CONDITION	Run No.	Total Drainage "Q" entering Canal	Total "Q" entering Canal	"Q" from Head Box	Depth at Gage Pt. No. 1	Velocity at Gage Pt. No. 1	"Q" from Inlet No. 1	Canal "Q"	"Q" Over Weir No. 1	Canal "Q"	Depth at Gage Pt. No. 2	Velocity at Gage Pt. No. 2	Depth at Gage Pt. No. 3	Velocity at Gage Pt. No. 3	"Q" from Inlet No. 2	Canal "Q"	Depth at Gage Pt. No. 4	Velocity at Gage Pt. No. 4	"Q" over Weir No. 2	Canal "Q"	Depth at Gage Pt. No. 5	Velocity at Gage Pt. No. 5	Total "Q" over Weirs
		cfs	cfs	cfs	ft.	ft/sec	cfs	cfs	cfs	cfs	ft	ft/sec	ft	ft/sec	cfs	cfs	ft	ft/sec	cfs	cfs	ft	ft/sec	cfs
Drainage flow enters canal U.S. & D.S. of Weir No. 1. Weir No. 1 full length. Weir No. 2 closed.	2	475	675	350	5.91	2.83	115	465	355	110	5.94	0.88	5.96	Approx. same as at Pt. 2	210	320	5.81	2.66	Closed	320	5.80	Approx same as at Pt. 4	355
	3	440	640	315	5.99	2.50	115	430	337	93	5.88	0.76	5.93		210	303	5.76	2.55		303	5.76		337
	1	410	610	285	5.93	2.30	115	400	307	93	5.82	0.77	5.85		210	303	5.67	2.61		307	5.71		307
	8	200	400	300	5.38	2.78	None	300	142	158	5.47	1.43			100	258				258	5.38		142
	12	200	400	300	5.35	2.80	"	300	138	162	5.43	1.48			100	262				262			138
Drainage flow enters canal U.S. of Weir No. 1. Weir No. 1 full length. Weir No. 2 closed.	10	265	465	350	5.83	2.89	115	465	186	279	5.56	2.47	5.34		None	279			Closed	279			186
	5	200	400	285	5.66	2.46	115	400	129	271	5.40	2.50	5.34		"	271	5.42	2.49		271	5.43		129
	6	200	400	400	5.37	3.72	None	400	126	274	5.42	2.52	5.39		"	274	5.46	2.49		274	5.48		126
	9	150	350	350	5.29	3.33	"	350	94	256	5.33	2.41			"	256				256	5.38		94
	11	100	300	300	5.16	2.94	"	300	53	247	5.19	2.40			"	247				247			53
	4	85	285	285	5.11	2.84	"	285	45	240	5.15	2.36	5.10		"	240	5.18	2.34		240	5.19		45
Drainage flow enters canal D.S. from Weir No. 1. Weir No. 1 full length. Weir No. 2 closed.	7	200	400	200	5.36	1.86	None	200	145	55	5.47	0.50	5.47		200	255	5.33	1.87	Closed	255	5.33		145
	13	100	300	200	5.17	1.96	"	200	65	135	5.25	1.30			100	235				235			65

BOULDER CREEK SUPPLY CANAL
TEST DATA
1:12 SCALE MODEL

FIGURE 14
Report Hyd 407

TEST NO. 19

NOTE: See Figures 5 and 7 for Location Diagram

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TEST CONDITION	Run No.	Total Drainage "Q" entering Canal cfs	Total "Q" entering Canal cfs	"Q" from Head Box cfs	Depth at Gage Pt. No. 1 ft	"Q" from Inlet No. 1 cfs	Canal "Q" cfs	"Q" over Weir No. 1 cfs	Canal "Q" cfs	Depth at Gage Pt. No. 2 ft	Depth at Gage Pt. No. 3 ft	"Q" from Inlet No. 2 cfs	Canal "Q" cfs	Depth at Gage Pt. No. 4 ft	"Q" over Weir No. 2 cfs	Canal "Q" cfs	Depth at Gage Pt. No. 5 ft	Total "Q" over Weirs cfs
Weir No. 1 half length (crest 51 feet). Weir No. 2 closed.	3	330	530	530	5.77	None	530	193	337	5.90	5.86	None	337	5.95	Closed	337	5.95	193
	2	325	525	252	6.30	273	525	202	323	5.89	5.84	None	323	5.93		323	5.93	202
	8	325	525	252	5.84	None	252	216	36	5.94	5.96	273	309	5.77		309	5.75	216
	1	162	362	226	5.73	136	362	93	269	5.44	5.41	None	269	5.47		269	5.48	93
Weir No. 1 full length (crest 102 feet). Weir No. 2 closed.	4	330	530	530	5.52	None	530	214	316	5.66	5.61	None	316	5.71	Closed	316	5.71	214
	5	325	525	252	6.09	273	525	220	305	5.65	5.59	None	305	5.67		305	5.70	220
	7	325	525	252	5.54	None	252	241	11	5.69	5.72	273	284	5.52		284	5.51	241
	6	162	362	226	5.65	136	362	110	252	5.36	5.30	None	252	5.35		252	5.37	110

TEST NO. 16

Weir No. 1 closed. Weir No. 2 full length (crest 107 feet).	1	325	525	200	6.41	115	315	Closed	315	6.31	6.25	210	525	5.54	224	301	5.78	224
	6	300	500	285	6.31	115	400		400	6.10	5.97	100	500	5.52	201	299	5.70	201
	3	295	495	285	6.13	None	285		285	6.15	6.14	210	495	5.50	198	297	5.70	198
	5	265	465	350	6.21	115	465		465	5.82	5.60	None	465	5.44	176	289	5.64	176
	2	210	410	200	5.82	None	200		200	5.89	5.90	210	410	5.40	132	278	5.52	132
	4	200	400	285	5.95	115	400		400	5.62	5.43	None	400	5.35	125	275	5.50	125
	8	115	315	200	5.60	115	315		315	5.33	5.20	None	315	5.20	63	252	5.29	63
	7	85	285	285	5.20	None	285		285	5.19	5.10	None	285	5.12	42	243	5.22	42

BOULDER CREEK SUPPLY CANAL
TEST DATA
1:12 SCALE MODEL

FIGURE 1[illegible]
Report Hyd 407

NOTE: See Figures 5 and 7 for Location Diagram

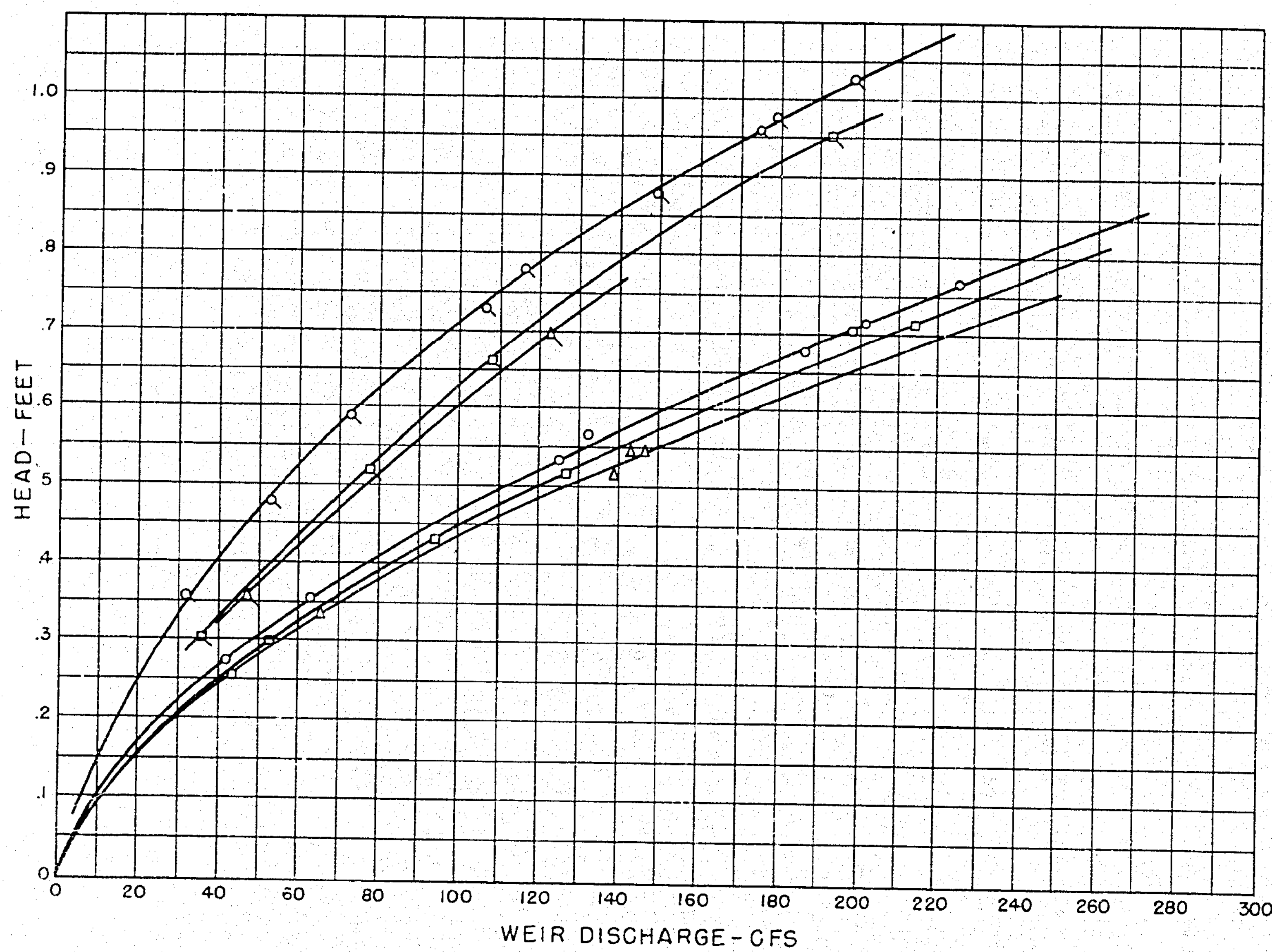
TEST NO. 17

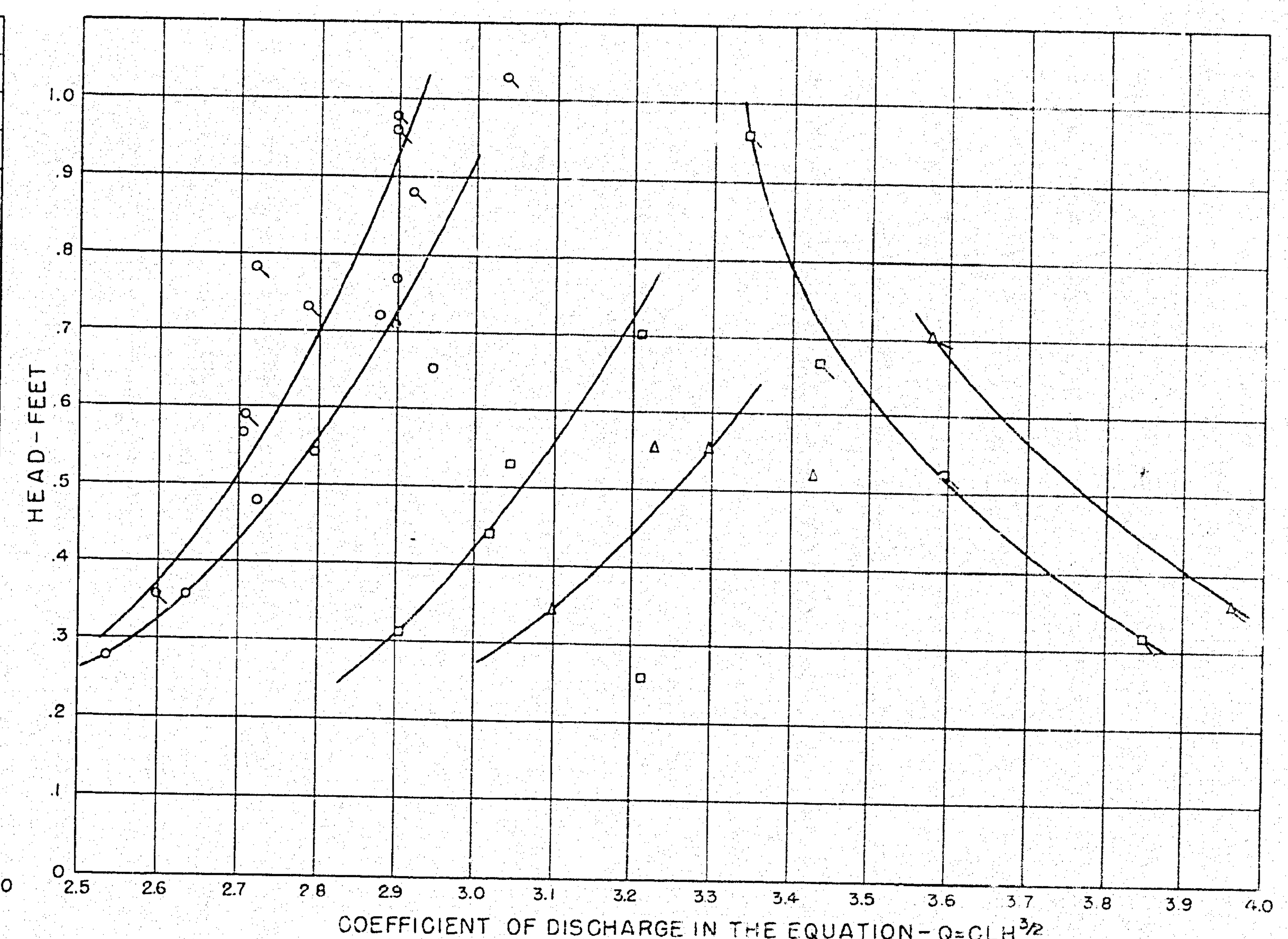
TEST CONDITION	1 Run No.	2 Total Drainage "Q" entering Canal cfs	3 Total "Q" entering Canal cfs	4 "Q" from Head Box cfs	5 Depth at Gage Pt. No. 1 ft	6 "Q" from Inlet No. 1 cfs	7 Canal "Q" cfs	8 "Q" Over Weir No. 1 cfs	9 Canal "Q" cfs	10 Depth at Gage Pt. No. 2 ft	11 Depth at Gage Pt. No. 3 ft	12 "Q" from Inlet No. 2 cfs	13 Canal "Q" cfs	14 Depth at Gage Pt. No. 4 ft	15 "Q" over Weir No. 2 cfs	16 Canal "Q" cfs	17 Depth at Gage Pt. No. 5 ft	18 Total "Q" over Weirs cfs
Weir No. 1 closed. Weir No. 2 half length (crest 53.5 feet).	1	325	525	200	6.55	115	315	Closed	315	6.44	6.40	210	525	5.86	197	328	6.00	197
	6	300	500	285	6.47	115	400		400	6.25	6.17	100	500	5.81	178	322	5.94	178
	3	295	495	285	6.29	None	285		285	6.32	6.31	210	495	5.78	172	323	5.93	172
	5	265	465	350	6.31	115	465		465	5.96	5.80	None	465	5.71	148	317	5.83	148
	2	210	410	200	5.96	None	200		200	6.02	6.03	210	410	5.63	115	295	5.71	115
	4	200	400	285	6.07	115	400		400	5.73	5.60	None	400	5.57	106	294	5.67	106
	9	150	350	350	5.58	None	350		350	5.53	5.42	None	350	5.43	73	277	5.52	73
	8	115	315	200	5.70	115	315		315	5.42	5.33	None	315	5.35	53	262	5.40	53
	7	85	285	285	5.28	None	285		285	5.26	5.18	None	285	5.23	32	253	5.28	32

TEST No. 18

TEST CONDITION	1 Run No.	2 Total Drainage "Q" entering Canal cfs	3 Total "Q" entering Canal cfs	4 "Q" from Head Box cfs	5 Depth at Gage Pt. No. 1 ft	6 "Q" from Inlet No. 1 cfs	7 Canal "Q" cfs	8 "Q" Over Weir No. 1 cfs	9 Canal "Q" cfs	10 Depth at Gage Pt. No. 2 ft	11 Depth at Gage Pt. No. 3 ft	12 "Q" from Inlet No. 2 cfs	13 Canal "Q" cfs	14 Depth at Gage Pt. No. 4 ft	15 "Q" over Weir No. 2 cfs	16 Canal "Q" cfs	17 Depth at Gage Pt. No. 5 ft	18 Total "Q" over Weirs cfs
Weir No. 1 Half Length (crest 51 feet). Weir No. 2 closed.	2	475	675	350	6.31	115	465	330	135	6.27	6.30	210	345	6.15	Closed	345	6.14	330
	1	410	610	285	6.20	115	400	285	115	6.12	6.16	210	325	6.02		325	6.00	285
	5	330	530	390	6.18	140	530	214	316	5.90	5.86	None	316	5.97		316	5.95	214
	6	330	530	390	5.83	None	390	218	172	5.93	6.01	140	312	5.88		312	5.87	218
	4	265	465	350	5.96	115	465	163	302	5.75	5.69	None	302	5.77		302	5.79	163
	3	230	430	315	5.84	115	430	132	298	5.61	5.57	None	298	5.65		298	5.66	132
	9	200	400	400	5.61	None	400	108	292	5.56	5.52	None	292	5.60		292	5.62	108
	10	200	400	200	5.52	None	200	122	78	5.62	5.67	200	278	5.49		278	5.47	122
	12	200	400	200	5.90	200	400	114	286	5.58	5.51	None	286	5.58		286	5.47	114
	8	150	350	350	5.38	None	350	78	272	5.42	5.37	None	272	5.43		272	5.46	108
	7	85	285	285	5.17	None	285	36	247	5.19	5.16	None	247	5.23		247	5.24	38
	11	35	285	200	5.21	None	200	46	152	5.26	5.28	85	237	5.18		237	5.21	48
	13	85	285	200	5.41	85	285	44	241	5.21	5.14	None	241	5.22		241	5.24	44

BOULDER CREEK SUPPLY CANAL
TEST DATA
1:12 SCALE MODEL

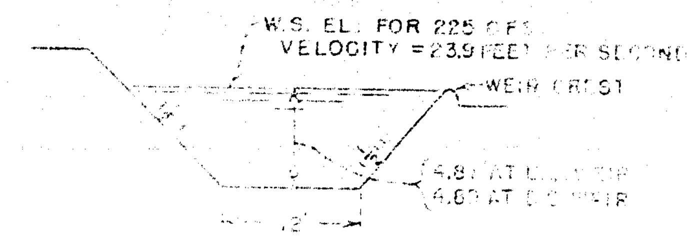




NOTE

Only the weir tested was open.
The head (H) is the average difference in elevation of the weir crest and the water surface at ℄ of canal upstream and downstream of weir.
"L" is the crest length equal to the weir length plus 10 (H).
The upstream tests are believed to more truly represent prototype conditions (see text). Therefore, disregard tests No's. 16 and 17 in using this data to predict weir discharges for future designs.

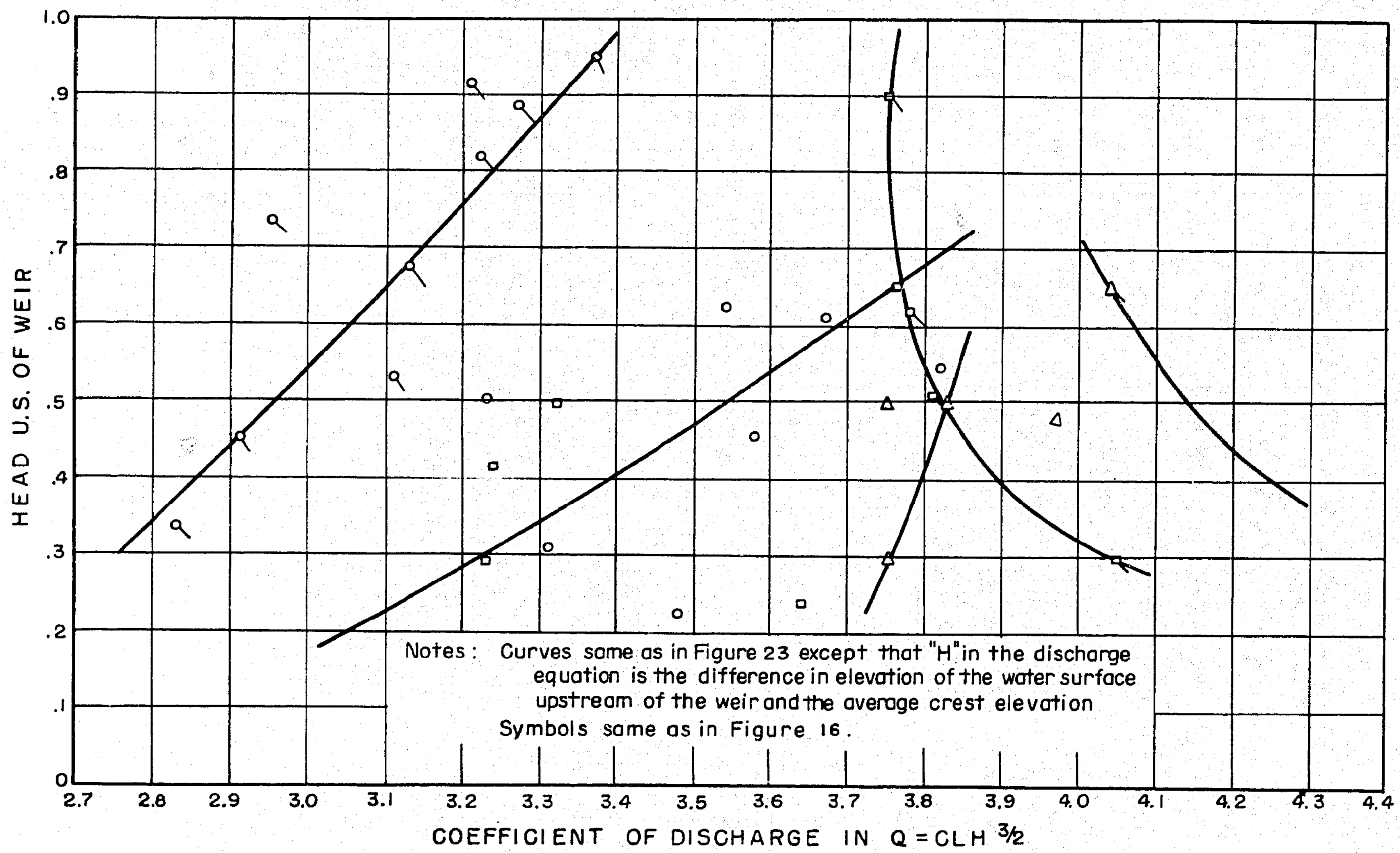
DATA SYMBOL	TEST NO.	RUN NO.	FIGURE NO.	WEIR TESTED	CREST LENGTH	TEST CONDITIONS
○	16	1 thru 8	14	D.S.	107 feet	— All drainage flow enters canal upstream of weir.
□	{13} {19}	{6,9,11 & 4} {4}	{13} {14}	U.S.	102 feet	— All drainage flow enters canal at head box upstream from weir.
△	13	7,8,12 & 13	13	U.S.	102 feet	— All drainage flow enters canal downstream from weir
○\	17	1 thru 9	15	D.S.	53.5 feet	— All drainage flow enters canal upstream from weir.
□\	{18} {19}	{9,8 & 7} {3}	{15} {14}	U.S.	51.0 feet	— All drainage flow enters canal at head box upstream from weir.
△\	18	10 & 11	15	U.S.	51.0 feet	— All drainage flow enters canal downstream from weir.



CANAL CROSS SECTION
AT WEIR

BOULDER CREEK SUPPLY CANAL
WEIR DISCHARGE CURVES
1:12 SCALE MODEL

537

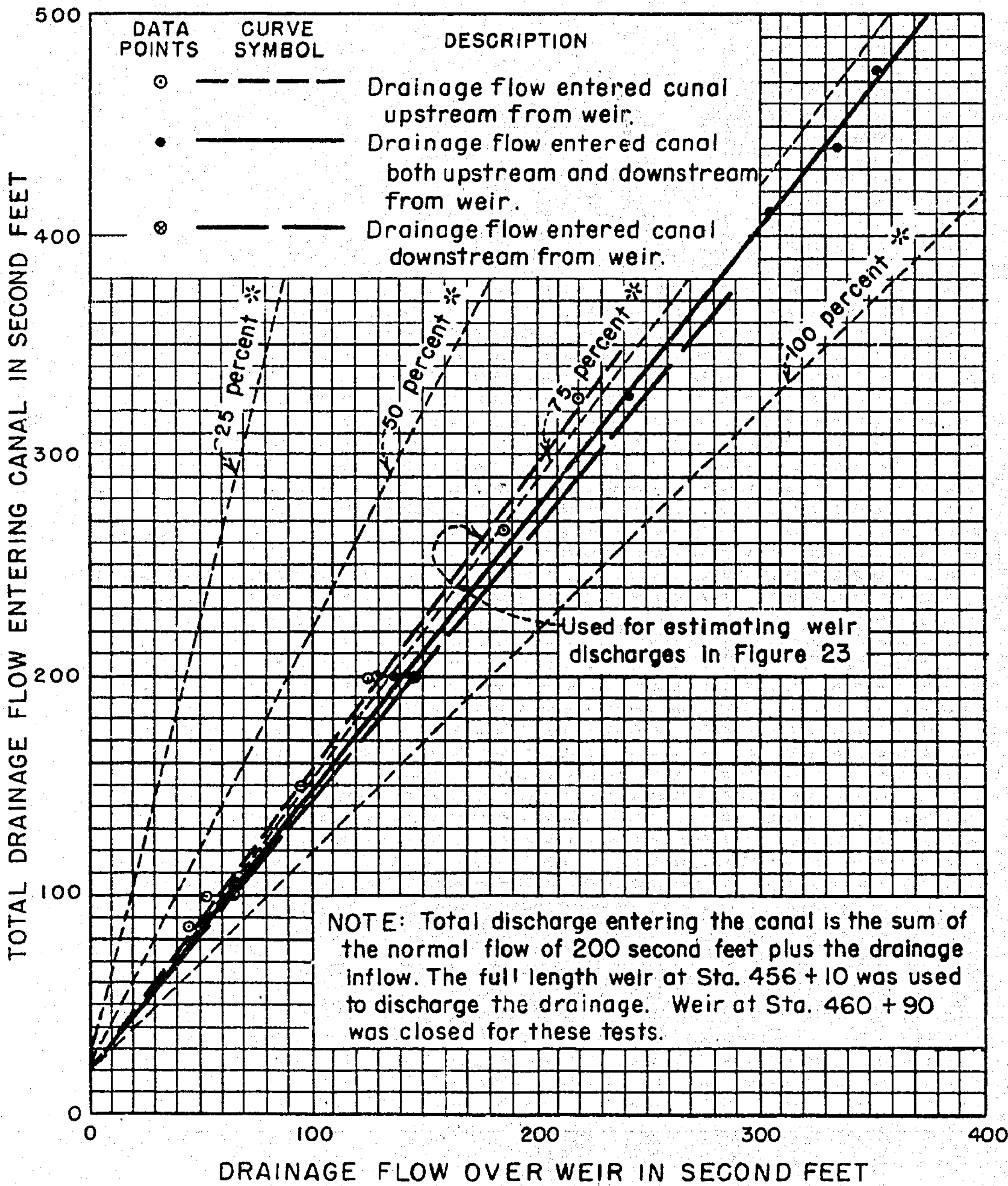


BOULDER CREEK SUPPLY CANAL

COEFFICIENT OF DISCHARGE CURVES

1:12 SCALE MODEL

FIGURE 17
REPORT HYD 407



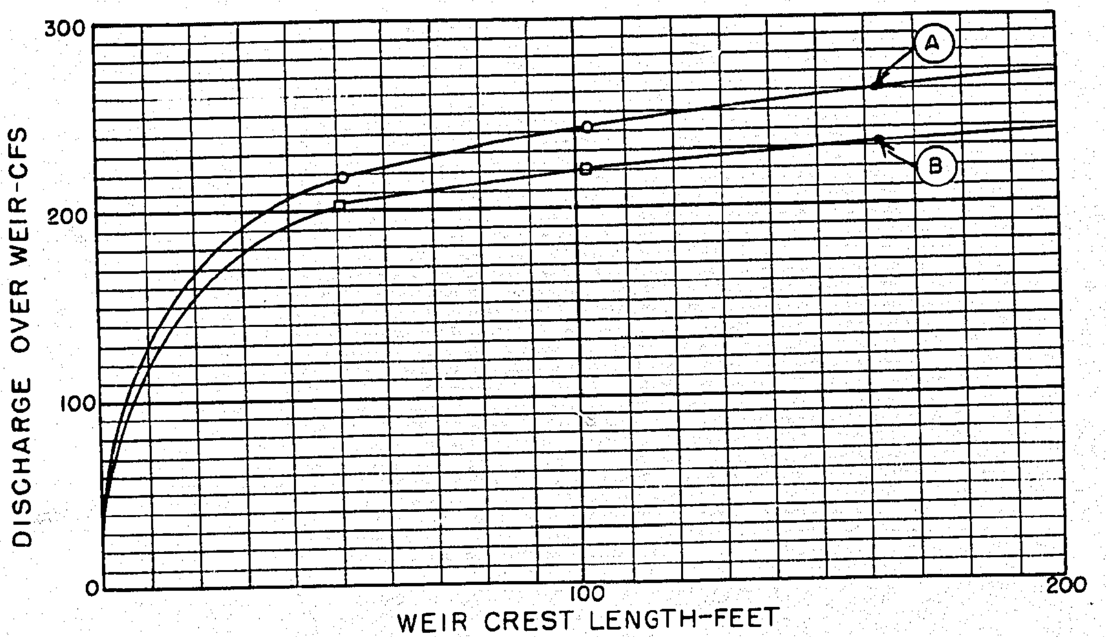
Data points are from Test 13 Figure 13 and from Runs 5 and 7 in Test 19, Figure 14.

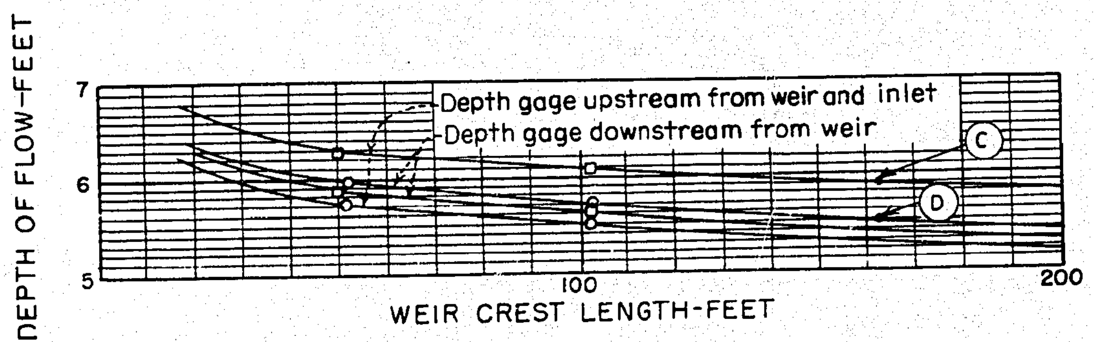
* Percent of total drainage inflow in excess of 20 second feet discharged by the weir.

BOULDER CREEK SUPPLY CANAL

CAPACITY OF WEIR WHEN LOCATED UPSTREAM, DOWNSTREAM, OR BETWEEN DRAINAGE INLETS

1:12 SCALE MODEL





SYMBOL CONDITION

□ (Preliminary) 273 cfs entered canal from drainage inlet at Sta. 358 + 95 upstream from weir.

○ (Revised) 273 cfs entered canal from drainage inlet at Sta. 358 + 95 downstream from weir.

NOTES

Data are from runs 2, 5, 7, & 8 in test 19, Figure 14.

The upstream weir in Figure 5 was used. The downstream weir was closed. Normal canal flow of 200 cfs plus 52 cfs of drainge flow entered the canal from the head box and 273 cfs entered canal from either the upstream or downstream drainage inlet. See Figures 5 and 7 for location of inlets and depth gages with respect to the weir.

BOULDER CREEK SUPPLY CANAL

WEIR DISCHARGE AND DEPTH OF FLOW AT STA. 360+00 FOR MAXIMUM FLOOD CONDITION

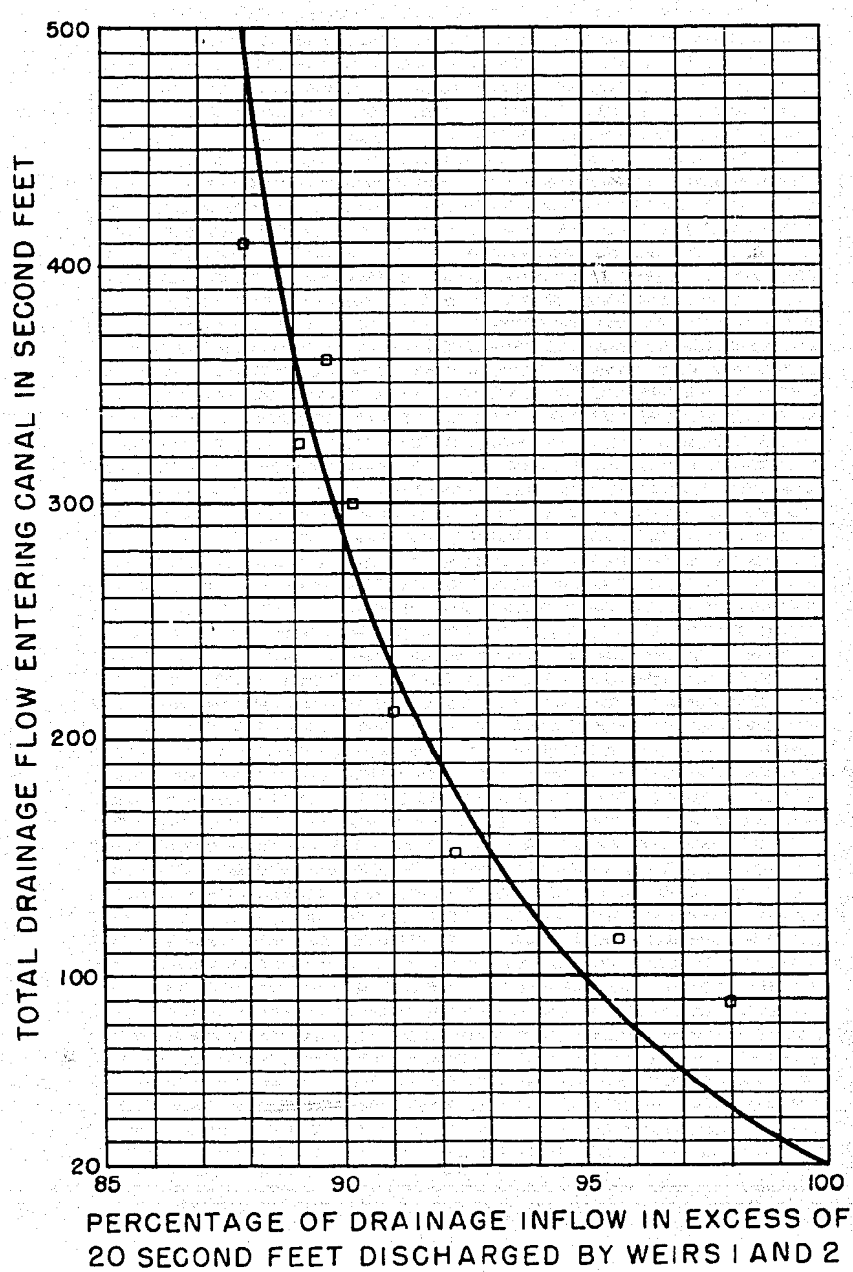
1:12 SCALE MODEL

TEST NO. 11

Note: See Figures 5 and 7 for Location Diagram

TEST CONDITION	1 Run No.	2 Total Drainage "Q" entering Canal	3 Total "Q" entering Canal	4 "Q" from Head Box	5 Depth at Gage Pt. No. 1	6 Velocity at Gage Pt. No. 1	7 "Q" from Inlet No. 1	8 Canal "Q"	9 "Q" over Weir No. 1	10 "Q" remaining in Canal	11 Depth at Gage Pt. No. 2	12 Velocity at Gage Pt. No. 2	13 Depth at Gage Pt. No. 3	14 Velocity at Gage Pt. No. 3	15 "Q" from Inlet No. 2	16 Canal Q	17 Depth at Gage Pt. No. 4	18 Velocity at Gage Pt. No. 4	19 "Q" over weir No. 2	20 "Q" remaining in Canal	21 Depth at Gage Pt. No. 5	22 Velocity at Gage Pt. No. 5	23 Total "Q" over Weirs
		cfs	cfs	cfs	ft.	sec	cfs	cfs	cfs	cfs	ft	ft/sec	ft	ft/sec	cfs	cfs	ft	ft/sec	cfs	cfs	ft	ft/sec	cfs
Preliminary Design (both weirs full length).	1	410	610	285	5.81	2.37	115	400	250	150	5.70	1.28	5.70	1.28	210	360	5.28	3.43	93	267	5.37	2.48	343
	8	360	560	350	5.48	3.15	None	350	220	130	5.64	1.12	5.66	1.12	210	340	5.25	3.25	85	255	5.33	2.38	305
	2	323	523	200	5.67	1.72	113	313	200	113	5.59	0.99	5.59	0.99	210	323	5.23	3.11	72	251	5.30	2.37	272
	5	295	495	285	5.41	2.61	None	285	181	104	5.54	0.92	5.56	0.92	210	314	5.21	3.03	67	247	5.28	2.35	248
	4	210	410	200	5.29	1.90	"	200	127	73	5.41	0.67	5.43	0.67	210	283	5.13	2.79	46	237	5.18	2.31	173
	7	150	350	350	5.16	3.43	"	350	69	281	5.21	2.71	5.11	2.78	None	281	5.12	2.78	51	230	5.22	2.21	120
	3	113	313	200	5.34	1.85	113	313	55	258	5.13	2.54	5.05	2.60	"	258	5.07	2.59	34	224	5.15	2.20	89
	6	85	285	285	5.05	2.88	None	285	36	249	5.08	2.49	5.01	2.54	"	249	5.05	2.52	28	221	5.12	2.19	64

BOULDER CREEK SUPPLY CANAL
TEST DATA
1:12 SCALE MODEL

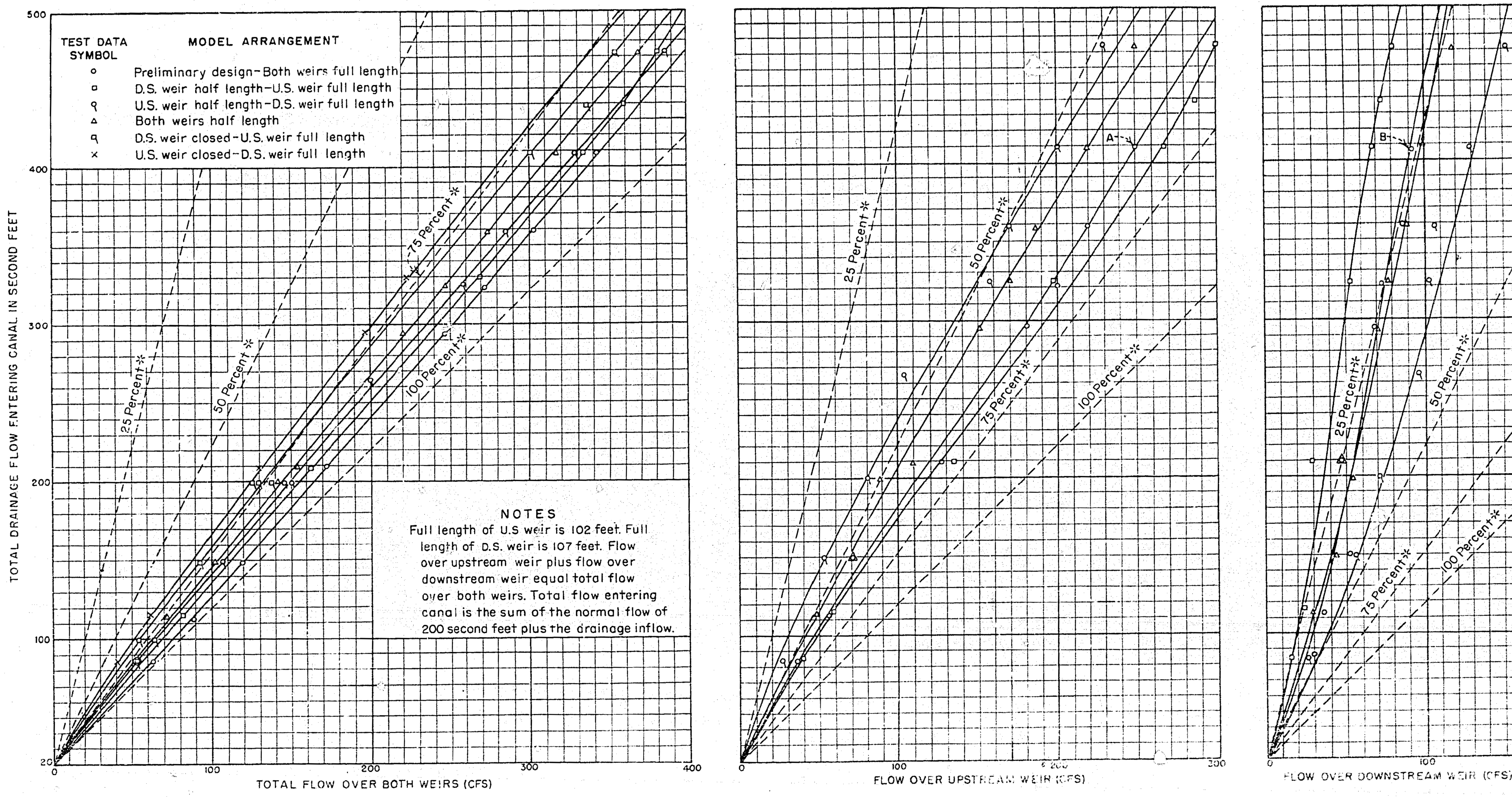


This curve was derived from data Test 11 in Figure 20.
Total discharge entering canal is the sum of the normal flow of 200 second feet plus the drainage inflow.

BOULDER CREEK SUPPLY CANAL

PERCENT OF DRAINAGE FLOW DISCHARGED BY THE WEIRS

1 : 12 SCALE MODEL



* Percent of total drainage inflow in excess of 20 second feet discharged by the weirs.

BOULDER CREEK SUPPLY CANAL
OVERFLOW WEIR CAPACITIES FOR VARIOUS WEIR LENGTHS
1:12 SCALE MODEL

537

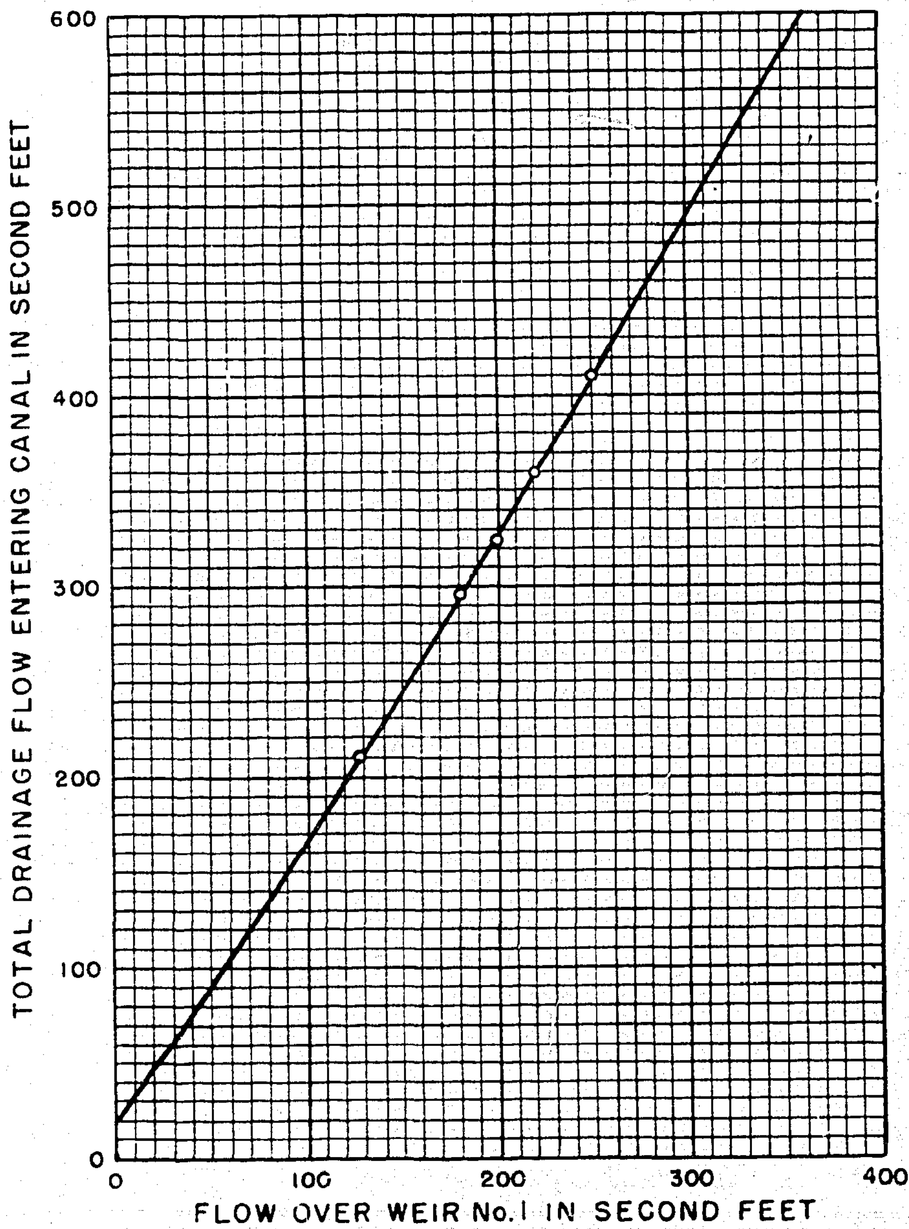
Figure 23
Report No. Hyd-407

Structure	Station	Weir length ft	Drainage discharge entering canal cfs	Discharge over weir cfs*	Discharge in canal cfs
Canal					200
Inlet	305+55		52		
Inlet	358+95		273		
					525
Weir	360+00	163		220	
					305
Inlet	413+00		87		
Inlet	435+00		138		
					530
Weir	436+25	113		225	
					305
Inlet	450+20		85		
Inlet	455+25		115		
					505
Weir	456+10	102		210	
					295
Inlet	458+80		210		
					505
Weir	460+03	107		210	
					295

*Weir discharges are estimated from Figure 18 which is for a weir 102 feet long. Enter Figure 18 with total drainage flow entering the canal upstream of each weir.

Boulder Creek Supply Canal
FIRST DRAINAGE FLOW ANALYSIS
1:12 SCALE MODEL

FIGURE 24
REPORT HYD. 407



Data points are from runs 1,8,2,5 and 4 in test No.11 in Figure 20. Weir No.2 is open and discharging. Weir length is 102 feet plus 10 to 1 end slopes. Total flow entering the canal is the sum of the normal flow 200 second feet plus the drainage inflow.

BOULDER CREEK SUPPLY CANAL

CAPACITY OF A WEIR BETWEEN INLETS AND OTHER WEIRS

1:12 SCALE MODEL

Structure	Station	Weir length ft	Drainage discharge entering canal cfs	Discharge over weir cfs*	Discharge in canal cfs
Canal					200
Inlet	305+55		52		
Inlet	358+95		273		
					525
Weir	360+00	163		340	
					185
Inlet	413+00		87		
Inlet	435+00		138		
					410
Weir	436+25	113		250	
					160
Inlet	450+20		85		
Inlet	455+25		115		
					360
Weir	456+10	102		225	
					135
Inlet	458+80		210		
					345
Weir	460+03	107		**90	
					255

*Weir discharges are estimated from Figure 24 which is for a weir 102 feet long. Enter Figure 24 with total drainage flow entering the canal upstream and downstream of each weir.

**Estimated from Figure 18 which is for a weir 102 feet long. Enter Figure 18 with total drainage flow entering the canal upstream of each weir.

Boulder Creek Supply Canal
SECOND DRAINAGE FLOW ANALYSIS
1:12 SCALE MODEL

Figure 26
Report No. Hyd-407

Structure	Station	Weir length ft	Drainage discharge entering canal cfs	Discharge over weir cfs*	Discharge in canal cfs
Canal					200
Inlet	305+55		52		
					252
Weir	356+92	163		200	
					52
Inlet	358+95		273		
					325
Weir	412+24	102		215	
					110
Inlet	413+00		87		
Inlet	435+00		138		
					335
Weir	436+25	113		130	
					205
Inlet	450+20		85		
					290
Weir	451+26	102		120	
					170
Inlet	455+25		115		
					285
Weir	456+10	102		180	
					105
Inlet	458+80		210		
					315
Weir	460+03	107		**70	
					245

*Weir discharges are estimated from Figure 24 which is for a weir 102 feet long. Enter Figure 24 with total drainage flow entering the canal upstream and downstream of each weir.

**Estimated from Figure 18 which is for a weir 102 feet long. Enter Figure 18 with total drainage flow entering the canal upstream of each weir.

Boulder Creek Supply Canal
DRAINAGE FLOW ANALYSIS OF THE RECOMMENDED DESIGN
1:12 SCALE MODEL

GPO 841190